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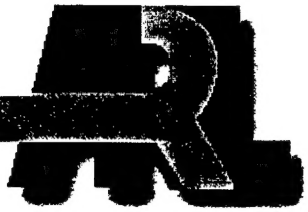

Experimental Interrogation of Network Simulation Models of Human Task and Workload Performance in a U.S. Army Tactical Operations Center

Sam E. Middlebrooks

ARL-RP-0036 OCTOBER 2001

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Sam E. Middlebrooks
Human Research & Engineering Directorate

Abstract

This thesis research is involved with the development of new methodologies for enhancing the experimental use of computer simulations to optimize predicted human performance in a work domain. Using a computer simulation called Computer modeling Of Human Operator System Tasks (CoHOST) to test the concepts in this research, methods are developed that are used to establish confidence limits and significance thresholds by having the computer model self report its limits. These methods, along with experimental designs that are tailored to the use of computer simulation instead of human subject based research, are used in the CoHOST simulation to investigate the U.S. Army battalion level command and control work domain during combat conditions and develop recommendations about that domain based on the experimental use of CoHOST with these methodologies. Further, with the realization that analytical results showing strictly numerical data do not always satisfy the need for understanding by those who could most benefit from the analysis, the results are further interpreted in accordance with a team performance model and the CoHOST analysis results are mapped to it according to macroergonomic and team performance concepts.

The CoHOST computer simulation models were developed based on Army needs stemming from the Persian Gulf war. They examined human mental and physical performance capabilities resulting from the introduction of a new command and control vehicle with modernized digital communications systems. Literature searches and background investigations were conducted, and the CoHOST model architecture was developed that was based on a taxonomy of human performance. A computer simulation design was implemented with these taxonomic based descriptors of human performance in the military command and control domain using the commercial programming language MicroSaintT". The original CoHOST development project developed results that suggested that automation alone does not necessarily improve human performance.

The CoHOST models were developed to answer questions about whether human operators could operate effectively in a specified work domain. From an analytical point of view this satisfied queries being made from the developers of that work domain. However, with these completed models available, the intriguing possibility now exists to allow an investigation of how to optimize that work domain to maximize predicted human performance. By developing an appropriate experimental design that allows evaluative conditions to be placed on the simulated human operators in the computer model rather than live human test subjects, a series of computer runs are made to establish test points for identified dependent variables against specified

independent variables. With these test points a set of polynomial regression equations are developed that describe the performance characteristics according to these dependent variables of the human operator in the work domain simulated in the model. The resulting regression equations are capable of predicting any outcome the model can produce. The optimum values for the independent variables are then determined that produce the maximum predicted human performance according to the dependent variables.

The conclusions from the CoHOST example in this thesis complement the results of the original CoHOST study with the prediction that the primary attentional focus of the battalion commander during combat operations is on establishing and maintaining an awareness and understanding of the situational picture of the battlefield he is operating upon. Being able to form and sustain an accurate mental model of this domain is the predicted predominant activity and drives his ability to make effective decisions and communicate those decisions to the other members of his team and to elements outside his team.

The potential specific benefit of this research to the Army is twofold. First, the research demonstrates techniques and procedures that can be used without any required modifications to the existing computer simulations that allow significant predictive use to be made of the simulation beyond its original purpose and intent. Second, the use of these techniques with CoHOST is developing conclusions and recommendations from that simulation that Army force developers can use with their continuing efforts to improve and enhance the ability of commanders and other decision makers to perform as new digital communications systems and procedures are producing radical changes to the paradigm that describes the command and control work domain.

The general benefits beyond the Army domain of this research fall into the two areas of methodological improvement of simulation based experimental procedures and in the actual application area of the CoHOST simulation. Tailoring the experimental controls and development of interrogation techniques for the self-reporting and analysis of simulation parameters and thresholds are topics that bode for future study. The CoHOST simulation, while used in this thesis as an example of new and tailored techniques for computer simulation based research, has nevertheless produced conclusions that deviate somewhat from prevailing thought in military command and control. Refinement of this simulation and its use in an even more thorough simulation based study could further address whether the military decision making process itself or contributing factors such as development of mental models for understanding of the situation is or should be the primary focus of team decision makers in the military command and control domain.

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Experimental Interrogation Of Network Simulation Models Of Human Task And Workload Performance In A U.S. Army Tactical Operations Center

By
Sam E. Middlebrooks

Thesis to be submitted to the faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Master of Science

In

Industrial and Systems Engineering

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EXPERIMENTAL INTERROGATION OF NETWORK SIMULATION MODELS OF HUMAN TASK AND WORKLOAD PERFORMANCE IN A U.S. ARMY TACTICAL OPERATIONS CENTER

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DEDICATION

This thesis is dedicated to Betty, my wife, mother of my children, and my life partner. Her unfailing love, support and dedication, through over 30 years of marriage and a career that has spanned more than 25 years across two continents through too many locations to remember, has made me the person I am today. This effort would not have been possible without her.

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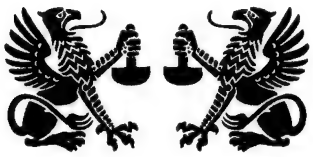
To all of you, Thankyou.



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1. Introduction.

Following the Persian Gulf War, when the U.S. Army determined that its current armored command and control vehicle was obsolete, the Human Research and Engineering Directorate of the U.S. Army Research Laboratory developed a series of computer simulation models to examine human mental and physical performance capabilities resulting from the introduction of a new vehicle with modernized digital communications systems. A computer simulation design was implemented with taxonomic based descriptors of human performance in the military command and control domain using the commercial programming language MicroSaint™. A series of computer models called Computer modeling Of Human Operator System Tasks (CoHOST) (Middlebrooks et al., 1999) was written and results were developed that addressed questions being posed by the developers of the new vehicle.

With these completed models on hand, the intriguing possibility exists to carry the research beyond the purpose of the original project and allow an investigation of how to optimize the simulated work domain to maximize predicted human performance. This thesis uses an experimental design to evaluate performance conditions to be placed on the simulated human operators in the computer model. A series of computer runs is then conducted to establish test points for identified dependent variables against specified independent variables. With these test points a set of polynomial regression equations is developed that describe the performance characteristics according to these dependent variables of the human operator in the work domain simulated in the model. The resulting regression equations are predictive of any outcome the model is capable of producing. Finally, the derivative of the equations is taken and set equal to zero to provide the optimum values for the independent variables that will produce the maximum human performance according to the dependent variables.

1.1. Review of the Literature.

The use of computer simulation as an exploratory tool to support experimental design is well documented in the literature. It can be thought of as a merging of the concepts of system simulation, system modeling and the use of the digital computer as a research aid (Whicker and Sigelman, 1991b). Five elements of a computer simulation are described as:

- Assumptions in the simulation.
- Parameters or fixed values providing input to the simulation.

- Independent variables providing input to the simulation.
- Algorithms embedded in the simulation.
- Simulation output contained in the dependent variables.

The steps that comprise the use of a computer simulation in a simulation based study include (Banks, Carson, and Nelson, 1996):

- Formulate the problem.
- Set objectives and develop a project plan.
- Conceptualize or design the model.
- Collect supporting data.
- Translate the model design into a computer simulation.
- Verify the simulation.
- Validate the simulation.
- Develop an experimental design based on the simulation.
- Perform simulation runs to gather data and then analyze it.
- Determine if additional runs are required.
- Report and document the results.
- Implement the results.

Other interpretations are applied to this process but the concept is basically the same (Law and Kelton, 2000):

- Problem formulation and study planning.
- Data collection and model definition.
- Validating the conceptual model.
- Write the computer program. Verify it.
- Perform pilot runs of the simulation.
- Validate the programmed model.
- Develop an experimental design based on the model.
- Perform simulation runs to gather data.
- Analyze the simulation data.

- Report, present, and employ the results.

A simulation is described as a numerical technique for conducting experiments on mathematical and logical models that describe the behavior of a system using a digital computer (Naylor and Gianturco, 1966). Naylor's process definition includes:

- Problem formulation.
- Data collection.
- Model formulation.
- Parameter estimation.
- Evaluation of the model and parameter estimates.
- Formulation of a computer program.
- Validation.
- Experimental design.
- Analysis of simulated data.

If this process has been performed to some stage of completion and a completed simulation model is available for use, then the real benefit of having a simulation model comes into existence. One use of such a model is the investigation of what combination of input variables will provide the optimal mix of the output variables (Clayton, Weber, and Taylor, 1982). Several approaches can be used to achieve this result. The first is a brute force approach whereby all possible combinations of the model inputs are evaluated for their output. When using factorial experimentation the combinations can become unmanageable very quickly even with the aid of the computer running simulated experiments. The second approach is to run selected combinations of input variables selected according to an experimental design and then use regression analysis to estimate the equations that will produce the output values. A third approach might be to use what is called a 'direct search procedure' that considers different objectives that does not require the knowledge of exact model equations.

The second approach described above can be employed in a manner where the simulation itself is simply considered to be a 'black box' where some translation of the input conditions is manipulated to produce a resulting set of output conditions (Smith, 1973; Smith and Mauro, 1981). With this method, one approach is to use a factorial design to evaluate the output for all combinations of the input factors. Then either select the input combination that produces the

best results or a set of points in a region and use them to fit a regression equation. This equation can then be used to predict the optimum values of the outputs.

Stasser (1990) noted that the use of computer simulation in social science research declined after an initial interest in the late 1960's. One reason that was postulated was that it is possible that simulations of social behavior can yield patterns of discrete and qualitative results that cannot easily be represented in statistical testing. It could be further stated that computer modeling of socio-technical interpersonal tasks is not an exact science. As an exploratory tool, simulation can be very useful for planning empirical research and for obtaining tentative answers to selected questions. It still requires good theorizing with intelligence, creativity and style from human theorists to make sense from the results of the simulation (Stasser, 1990). The primary purpose of a computer simulation supported experiment is to find a simple but accurate function that represents, over the region of interest, the true function comprising the computer model itself (Webb, 1970). While these references are from ten to thirty years ago they, nevertheless, illustrate a continuing lack of the use of computer simulations in support of empirical inquiry that has continued to exist. The purpose of this thesis is to address this shortcoming and demonstrate how well established procedures can be tailored to this type of research.

Specific areas of interest to this thesis topic that will be explored in the literature are the use of simulations with experimental designs, the use of simulations to describe human performance, and the use of regression analysis with computer simulations.

1.1.1. Use of Simulations With Experimental Designs.

The basic nature and process of interrogating simulation models according to a formal experimental design has been described and is well documented (Banks et al., 1996) (Law and Kelton, 2000). The use of these techniques in social science research apparently is not extensive (Stasser, 1990), but there is a continuing and significant effort being applied to the use of these principles both in industry and in academia.

For example, one experiment that used a replication count of 100,000 simulated 4 treatment groups of 16 subjects each that converted randomly drawn pairs from a uniform distribution into random normal deviates to evaluate the differences between Type I error rates for a variety of multiple comparisons (Klockars and Hancock, 1994). Another example used computer simulation to investigate problems connected with the genetic analysis of continuously variable behavioral patterns in human populations (Eaves, 1972). Environmental variation in

human populations has been investigated (Eaves, 1970), and interaction effects using constructed populations to investigate different hypotheses has been performed (Gabrielsson and Seeger, 1971). Techniques to deal with such issues as initialization bias of the independent variables in nonterminating simulations has been investigated and described (Schruben and Goldsman, 1984). One thesis that investigated predicted simulated human performance using empirically derived input data employed the commercial software package SAINT™ (System Analysis of Integrated Networks of Tasks) which was a predecessor to the MicroSAINT™ package in current use (Askren, 1976). In this case, the empirically derived data was manipulated into a set of linear regression equations that were used to provide input to the computer model. Another thesis using a commercial simulation package used the SIMSCRIPT II.5 discrete event simulation language to model the U.S. Army Corps of Engineer's construction change order processing procedure. This application included the use of the Ramberg-Schmeiser percentile probability distribution function and a regression analysis to model the network activities (Curtis, 1986). In another case, three computer simulation sessions investigated the impact of two response styles against the validity of results obtained from regression and factor analysis. This simulation study approach over a formal experimental design using human test subjects was selected to allow complete control over the manipulations, to enable the ability to vary the number of subjects in the test conditions, and to account for difficulties of analytical approaches when two response variables are combined (Heide and Gronhaug, 1992).

1.1.2. Use of Simulations to Describe Human Performance.

Early evolutions of the human computer interface have been described in terms of 1950's vintage technology as being much 'simpler' but far less effective (Muckler, 1987). This observation, made in the mid 1980's, commented that the technology was in a transition phase where nothing worked very well but the possibilities were exciting. Whether or not the truth of this observation has changed in the intervening 20 years is open to speculation, however, there are tools and disciplines that have emerged that directly address the nature of the problem.

The discipline of human computer interaction (HCI) has become a recognized field of study to investigate the unique nature of the interactions of a human system interface where the system is a computer or is computer based or driven. Investigations into this field discuss the concept of using models of the user as an interface design tool (Williges, 1987). Because of the

nature of HCI many times the computer is used to support experimental design investigations using the actual computer based system itself. This is not simulation based experimentation but rather testing where the system itself exists on a computer. An example of this was a study (Cohill and Williges, 1985) that used a 2^3 between subjects design to look at different forms of the HELP function on the computer. The actual simulation of the human component in an HCI system can become complicated and subject to review and introspection. A simulation of the single operator in a semiautomatic radar surveillance system using a time compressed real-time cathode ray tube display was conducted (Mills and Williges, 1973), and was followed by an assessment of the validity of the empirically derived prediction equations of the operator performance in this simulated system (Williges and Mills, 1973).

The concept of cognitive compatibility has been identified as a central component in the field of HCI and is a useful concept to account for user's behavior in this field (Streitz, 1987). Investigations of concepts such as this can be performed empirically with live human test subjects, however, the complex nature of the interactions involved are difficult to reproduce with subjects that may be available for only one or a few test sessions. Computer simulation provides the repeatability and manipulation ability to replicate many different test conditions with simulated test subjects that obediently perform as directed. Of course, the disadvantage of simulated test subjects is that they are only as cognitively complex as their programming allows and are typically suitable only for the test domain of the current simulation.

HCI has emerged as a research field because of the exploding technology that spawned it. Technology drives HCI and the most vital part in HCI design is the generation and utilization of basic generic research devoted to it (Salvendy, 1987). Using this technology to evolve the tools needed to study and improve it, such as with computer simulations, will enable positive outcomes to predictions from technical theorists such as Muckler and others.

1.1.3. Use of Regression Analysis With Computer Simulations.

It has already been observed that regression analysis can be a useful tool for taking the results of computer simulation and determining what the optimum value of the dependent variables might be (Smith, 1973). One example of this process was where data from a deterministic simulation model that was used to predict statistically noisy experimental data simulating the psychological processes in a language processing simulation was compared with single sentence reading times by fitting a linear equation to the reading times (Kieras, 1979).

Another example involved the use of a computer simulation to investigate moderated multiple regression techniques for moderating variables in industrial / organizational psychology research (Paunonen and Jackson, 1988). One simulation study looked at the tool itself by investigating the relative power of different moderated multiple regression techniques with or without a dichotomized moderator and correlational analysis (Mason, Tu, and Cauce, 1996).

The ability to take output from an experimental design study that has been generated either with or without a computer and apply algebraic manipulations to representations of that data to determine maximum and / or minimum performance limits can be a powerful technique for describing the performance domain.

1.2. Research Goals and Objectives.

The purpose of this thesis is twofold. First, and foremost, this project is to develop methodologies that expand the ability to use computer simulations to support human performance studies using experimental designs. Discussions of research implications and methodological procedures are conducted to explore these issues and to provide proposals and suggestions for the conduct of computer simulation based experiments along with proposed guidelines for the efficient conduct of such experiments. Secondly, this project uses these methods in a study that investigates an actual problem the U.S. Army is working to resolve. This issue is how to optimize human performance efficiency in a military command and control work team during combat operations.

1.2.1. Optimizing Experimental Designs Of Human Performance Using Computer Simulation.

The first step is to determine an experimental design appropriate for the investigation. While this statement may seem obvious, the normal compromises between design efficiency and analysis resolution desires require special consideration when the data is to be generated by a computer simulation. Current computer technology that allows the generation of large amounts of data in a relatively short time can foster the belief that designs that would be too large and complex to collect data upon in actual empirical study can be performed in a straightforward manner on the computer. While this might be true to a certain extent, the researcher nevertheless must exercise prudence in the selection of resolution and treatment levels for the study. Computer runs that produce Resolution V results, for example, produce results that are of no use if the data can only be analyzed and interpreted at the Resolution III level. The temptation to

gather as much as possible and then sort it out later should not be attempted just because the computer allows it to happen. A well thought out and efficient design that gathers just the data needed is just as important with the computer as it is with empirical study.

On the other hand, the use of the computer can make possible research attempts that would not be possible with human study participants because of considerations such as the number of factors in the design, unavailability or nonexistence of experimental apparatus, or other factors that would make the research too complex or too costly to perform. In cases like this, excess complexity in the experimental design can push the computer beyond its limits to perform in the time required to run the simulation and perform the number of replication runs required. In this situation, just as in conventional empirical work, an efficient design may make possible work that could not be performed for a full factorial experiment or in cases where the design is more complex than normal. Designs that have a number of factors of six or more and increasing numbers of treatment levels may not be realistically possible if it takes the computer hours to perform one replication run. In this case the design must be constrained to levels that are realistically possible with the computer. The importance, however, of determining the level of resolution possible in the analysis from the number of treatments in the data must ensure that the efficient design that is started with will enable the desired analyses after the data is collected. If it is determined that the initial design cannot support the desired or required level of analysis then other techniques such as sequential experimentation (Han, Williges, and Williges, 1997; Williges, Williges, and Han, 1992; Williges, Williges, and Han, 1993) should be explored and are just as appropriate with the computer as with conventional experimentation.

After weighing the capabilities and requirements of the simulation, the task is then to choose the basic design. The best solution is to just select a full factorial design. However, this may not be possible as previously discussed. Reasons that may preclude it are large numbers of experimental factors and time constraints on the available computer resources. The next choice is logically a fractional factorial design, a central composite design (CCD) or some combination of the two. If the variables are quantitative and there are only two treatment levels for each variable then the central composite design can provide good efficiency. However, the requirement for the variables to be quantitative limits the applicability of the CCD. Also, with only two treatment levels per variable it is only possible to examine linear components of the main effects in the output analysis. A fractional factorial design can overcome these limitations.

Typically, in human factors work the ability to interpret more than two-way interactions is not possible. A Resolution V experiment that resolves all two way interactions is achievable with many fractional factorial combinations. In some cases only the main effects can be interpreted and a Resolution III experiment that provides this is even more achievable with fractional factorial techniques. In fractional factorial designs, as with CCD's, the number of treatment levels also becomes an issue. If there are only two treatment levels then the ability to resolve higher order components in the output again is an issue. One possibility to overcome this limitation is to augment the 2^n design with one more treatment level. In many cases where there are only two treatment levels the ability to define a third center point treatment is a possibility. This type of design can be called an augmented design where the fractional factorial design with two treatment levels is augmented with one more treatment from the center point. This distinction is made as compared to expanding the number of treatments to a full 3^n fractional factorial design which would require that more treatments be conducted.

A final consideration in tailoring an experimental design for use with computer simulations is to consider unbalancing the treatment orders. Instead of having a set number, for example 3 or 5, of simulated subjects per treatment condition, a possibility is to reduce this number to only one. Then, if the design is augmented with another treatment level such as a center point treatment, pick a number of repetitions for this treatment that will keep the error term for the F ratio within an acceptable limit. The advantage in doing this is to reduce the number of required computer simulation runs to support the experimental design. The disadvantage is that error due to random variability in the computer simulation could be magnified to observable levels because the number of simulated subjects per treatment condition may not be enough to average out the effects.

There are also considerations to be made about the use of the simulation itself. The first is the well documented (Banks et al., 1996) procedure of using multiple replications of the computer simulation to hold the error limit relative to the mean to within an acceptable limit. This involves making multiple runs (replications) of the simulation and then averaging the results for each output variable to hold the results from the random variability to the desired limit. Alternatively, the results from each replication run can be treated as an individual treatment to be examined by the statistical analysis.

A technique that is unique to simulation based experimentation involves the use of dummy independent variables. This procedure evolves from the difficulty in determining the appropriate level of significance to use in interpreting *P* values from statistical run results for the dependent variables. While the commonly used values of .05, .01, or .001 can be used in a manual table lookup, a dynamic alternative is to query the model itself to establish the actual level of significance for random variability in the simulation. The technique involves the inclusion of another independent variable in the experimental design that is not recognized or used in the simulation. Treatment runs are made that include this dummy variable using preset treatment values that do not change from treatment to treatment and the output is analyzed for it. The *P* value for this variable then represents random or unmanipulated variability in the computer simulation. Using this value for the threshold cutoff for significance as opposed to one of the traditional levels, all the other variables are compared to it and those that are less than this threshold are deemed significant and those that are higher are not significant. The point of note is that this is a dynamically determined significance threshold for *this simulation* and a much tighter fit for regression equations can be determined and closer predictions for ANOVA calculations can be made using it.

The final component of this methodology and resulting series of guidelines includes a process many times omitted or neglected in conventional experimental studies. This component is the requirement to explain and interpret the results of statistical and experimental conclusions into terms that occupants and developers of the work domain in question can understand. In order to do this the evolving human factors sub discipline of macroergonomics along with team performance theory is invoked to link experimental results to understandable descriptions. The goal is to pick a viable and descriptive model from the literature that will provide the basis for a descriptive understanding of the CoHOST predictive implications.

1.2.2. A Simulation Example – U.S. Army Battalion Command And Control Team.

The methodology that has been described needs to be implemented in an actual study to prove its efficacy. Several factors should be considered in the selection of an appropriate simulation to use for experimental investigations. Regardless of whether a new or existing simulation is to be used, several questions must be addressed before it can be considered to be viable for the experiment. These questions include:

- What is the real world environment or scenario?

- What is the level of accuracy or replication in the simulation of the real world?
- How much realism is good enough?

Since no simulation is likely to ever completely replicate the conditions of the real world the simulation must be accepted for the level of realism existing in it. This acceptance of risk acknowledges the level of realism in the simulation and provides an implied willingness to accept the predictions from the simulation to support the real project being examined. These decisions for model acceptance can be enhanced through the use of subject matter experts (SME) that can explicitly describe what the real world scenario looks like and by technical experts who can describe the level of authenticity in the simulation algorithms and constructs but it is the experiment designer who must decide how much is good enough. Some of the reasons that the use of a computer simulation becomes viable over real world experimentation evolves from reasons as to why the real system cannot be fully exercised or tested. The system may be:

- Too costly.
- Too dangerous.
- Too timely (i.e., requires too much time to test).

The simulation may also be desired for its ability to train operators and controllers in a more cost effective or time effective manner.

For this thesis it is desired to use a simulation already in existence. There are a couple of reasons for this desire. First, this effort is not a simulation development effort but rather an experimental design and analysis effort. Second, in the government as in industry, there are countless simulations that get developed and used for a single purpose and then are shelved or discarded notwithstanding development costs that might be substantial in terms of money, time, and effort. A significant objective of this thesis is to demonstrate that a preexisting simulation can be taken and used unmodified to support 'what-if' types of studies that have the potential to far transcend the original purpose of the simulation. By taking such a simulation and manipulating its data according to an experimental design, the desire is to show that meaningful use can be made of it that may even outweigh the benefits from it's original use.

The computer simulation chosen to demonstrate this process is titled Computer modeling of Human Operator System Tasks (CoHOST) developed by the U.S. Army Research Laboratory. This was part of a multi-year, multi-million dollar effort to investigate whether human operators could operate more efficiently in a proposed new work domain characterized by next generation

digital communication systems inside a moving vehicle under combat conditions. After an investment of several million dollars over several years that primarily consisted of labor related costs for the project team, a series of CoHOST models were developed that made predictions for the answers to questions originally posed by the developers of the new work domain. After the final delivery of the CoHOST project data to the clients the project was terminated and the project team reassigned. As a fully operational computer simulation that was the product of an extensive design, development, programming and V&V (verification and validation) effort, coupled with the author's familiarity with and access to the simulation, CoHOST proved to be an excellent choice for this project. The fact that the original development project was over and the simulation existed in a static form not being constantly changed and updated by computer programmers made CoHOST an ideal candidate for consideration as a "black box" that could be used to stuff data into and receive results out of.

CoHOST also was an attractive tool because of the potential applicability of its design constructs for use in other work domains. The work group modeled by the original project consists of 23 members of a U.S. Army heavy maneuver battalion's command and control elements lead by the battalion's commanding officer. As battalion commander, this individual not only commanded the entire 1,000 member combat maneuver battalion, but also acted as team leader for the select group of individuals that populated the battalion's tactical operations center (TOC) during combat operations. This work domain is described as a time pressured, high stress, decision oriented environment where information is received from the outside world into the team, is processed by it resulting in decisions that are made primarily by the battalion commander and then the results of those decisions are passed back into the outside world in the form of commands, directives, and status reports. These same components of time pressure, stress, and requirements for decision making and communication can be used to describe many different work group situations that exist not only in the military, but also in other governmental agencies and the civilian sector. Hospital emergency room teams of doctors, nurses, and support staff have the same pressures to quickly assimilate information, make decisions, and then act upon those decisions. Other examples of work domains that could be addressed by a CoHOST like simulation include:

- Nuclear power plant control room.
- Combat ship command and control centers.

- Civil Emergency Action Centers.
- Railroad Dispatch Centers.
- Air Traffic Control Centers.

For the work domain investigated in the current CoHOST simulation, some of the important considerations are what are the communication requirements, who are the decision makers, and what is the most important activity to be performed by the decision makers. A list of some of these activities include:

- Decision making?
- Battlefield assessment?
- Development of accurate mental models?
- Sharing of mental models?
- Evaluating impact of decisions?
- Inter and intra team communication?

The original intent and use of CoHOST centered on whether the human operators could benefit and perform more effectively in this new work domain than they could in the old, existing battalion TOC work domain. The methodologies in this thesis now demonstrate how the simulation can be expanded from its original intent and address how to optimize that domain to maximize predicted human performance.

2. Description Of The Computer Simulation.

The new Command and Control Vehicle (C2V) was designed to have a two man crew for vehicle driving and movement control in the front cab with up to four computer workstations and two auxiliary "jump" seats in the rear working compartment. An auxiliary 40KW power generator provides power for the computer systems and associated radio transmission equipment for operation either while the vehicle is moving or stationary with the main engine powered down. From a hardware design viewpoint this integration of a modern vehicle platform with state of the art communications capabilities directly addresses anticipated current and future battlefield command and control requirements well into the next century. However, this vehicle and its systems are at the heart of a change of the operational paradigm in command and control Tactical Operations Centers (TOC's) that the Army is now undergoing. Figure 1 illustrates the components in an Army battalion level TOC of today.

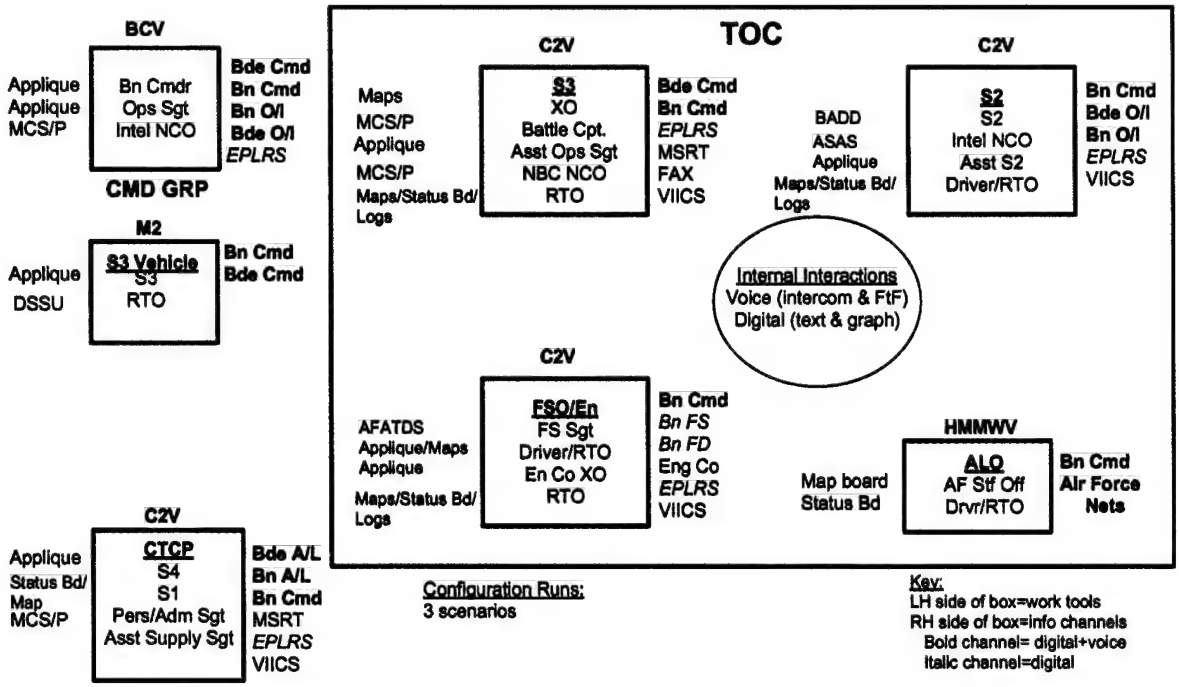

Figure 1 – Tactical Operations Center (TOC) Diagram
(Middlebrooks et al., 1999)

The rectangles represent the different vehicles in the unit. Personnel are listed inside the vehicle box and the communication systems for each vehicle are listed beside it. This select group of 24

people, along with the vehicles and communications systems they use, represent those people directly concerned with battlespace management and it is this working group that is modeled in CoHOST.

For the 50 years since World War II the fundamental nature, organization, and mode of operation of command organizations has remained unchanged. Staffs are organized on a basic four section structure and TOC's generally only operate in a totally static mode with the amount of time required to move them to keep up with a mobile battlefield going up almost exponentially from lower to higher command levels. However, current initiatives are changing all that and while new vehicles and hardware systems address the ability of the command structures to improve their operations, these initiatives do not necessarily provide the environment in which a human in the loop operator can necessarily function in a more effective manner.

This project addressed the ability of the human component of the new operational systems to perform under a new operational paradigm. As communications systems are passing greater and more accurate volumes of information in real time the question to be asked is 'can the soldier absorb this information and be able to react to the stream of data being presented to him/her also in real time?' Can these activities be performed while the vehicle is moving over extended distances and during extended time periods? Do the combined effects of fatigue, noise, and vibration that are sustained by an operator cause that person to become what is described as a "cognitive causality"? The CoHOST computer models and project looked at some of these issues and made recommendations, which are summarized here, that predicted the performance potential of human operators in this new working environment.

2.1. Application of a Taxonomy of Human Performance.

A With work first published in 1954, Edwin Fleishman (Fleishman, 1975) began what would turn into a lifetime effort focused on the development of taxonomic descriptors of work performance. The resulting taxonomy (Fleishman and Quaintance, 1984) presents a set of skills and abilities that can be used to describe human performance characteristics in any general work situation. Fleishman stated (Fleishman, 1975; Fleishman, 1978) that some kind of taxonomy of human performance is required which provides an integrative framework and common language applicable to a variety of basic and applied areas. He goes on further to state that it does appear that predictions and generalizations about human performance may be enhanced by some linkage

of task classification systems based on human abilities and task characteristics. In 1988 Fleishman (Fleishman, 1988) quoted earlier 1947 work by others with the observation that apparatus tests of perceptual motor abilities had been found to have considerable validity for predicting the success of pilots and bombardiers in getting through training during World War II.

Comments by others point out that Fleishman's work tends to be neglected in the mainstream of human information processing research, perhaps due to the fact that the skills and abilities in the taxonomy are only based on factor analyses and are void of any process description. However, the tests used by Fleishman to develop the taxonomy belong to the same type of performance tests that are studied in Wickens' more accepted dual task experiments and therefore deserve closer scrutiny (Sanders, 1997). There have been many attempts in the human factors community to develop similar descriptions of human performance and while this taxonomy may not be generally accepted by all for every attempt at evaluations of human performance, it does provide a set of skill and ability descriptors that are heavily weighted to cognitive performance.

Previous work at the U.S. Army Research Laboratory (ARL) (Knapp, 1996a; Knapp, 1996b; Knapp, Johnson, Barnette, Wojciechowski, Kilduff, Bird, and Plott, 1997c; Schipani et al., 1998), and the U.S. Army Research Institute (ARI) (Seven, Akman, Muckler, Knapp, and Burnstein, 1991) identified this job skill and ability taxonomy (Fleishman, 1984; Fleishman and Quaintance, 1984) and stated that it showed promise to provide the basis for workload scaling in Army battalion level command and control modeling efforts. This taxonomy consists of 52 skills and abilities that include mental processing, sensory perception and fine and gross motor skills. The selection of this taxonomy was influenced by its detailed decomposition of mental abilities and the existence of behaviorally anchored rating scales (Knapp et al., 1997c). Subsequently, 50 of the 52 skills and abilities from the taxonomy were adopted to support work that was performed for the U.S. Army Intelligence Center at Fort Huachuca, Arizona. This work sought to determine basic soldier training requirements needed to provide requisite skills and abilities for various Military Occupational Specialty (MOS) at the Intelligence Center's basic soldier training units. As shown in Figure 2, the taxonomy was grouped into eight demand categories of reasoning, speed-loaded, conceptual, communications, visual, auditory, psychomotor, and gross motor. Knapp stated that (Knapp et al., 1997c) " Each skill and ability has an associated behaviorally anchored rating scale that ranges from "1" for a very low level

demand, to "7" for the highest demand. Definitions for all 50 skills and abilities, along with their behaviorally anchored scales, is documented in a separate review of this taxonomy (Seven et al., 1991)."

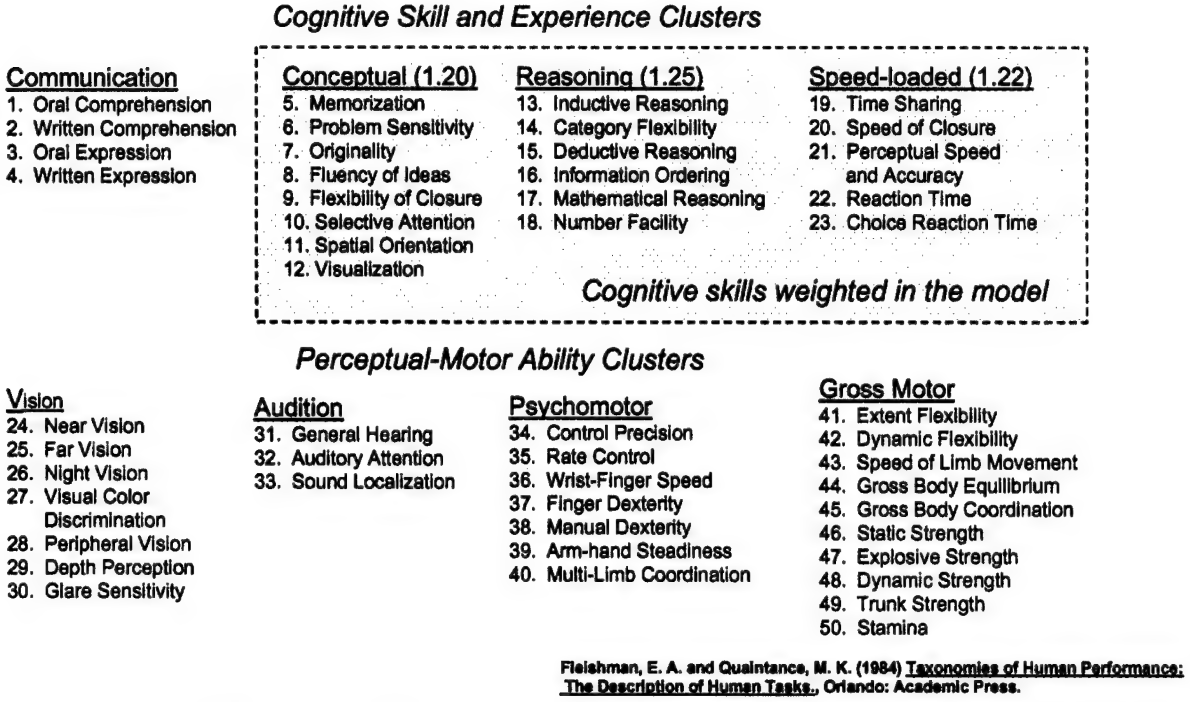

Figure 2 – Fleishman's Knowledge, Skills, and Abilities Taxonomy (Middlebrooks et al., 1999)

Using Fleishman's taxonomy, a database was developed using questionnaires using Likert – like 7 point behaviorally anchored questions and was administered to U.S. Army subject matter experts (SME). This questionnaire associated physical and mental skills and abilities from the taxonomy to performance tasks such as 'receive and record a radio message' that operators would be expected to execute in the performance of their duties in a TOC during the conduct of battlefield operations. This database then provided a numerical basis for a computer simulation model to calculate a workload estimate for each individual based on the tasks being performed at the instant of the calculation. The time interval selected for workload calculation updates was 100 seconds. Resulting from this, over the course of a simulation run, a profile of individual workload and utilization rates was established for each member of the workgroup at a 100 second resolution. The data was captured so that the workload rates could be decomposed into the individual elements of the taxonomy so that the amount of time spent by the individual in the different cognitive and physical performance categories could be determined. These

workload and utilization profiles were then analyzed following the simulation run using multivariate statistical techniques to predict whether individuals became cognitively saturated and therefore unable to effectively perform their assigned tasks.

2.2. Tactical Scenario.

The Battalion task force mission was modeled as a force-on-force operation occurring over several hours. Different scenarios that were developed include the phases of pre-operations planning, movement-to-contact, deliberate defense, and hasty attack. Some scenarios reflect heavy combat actions and others reflect extended movement and reconnaissance type operations as shown in Figure 3. A model input file consisting of scenario voice and digital messages expected to be sent to and from the battalion during the course of the tactical mission was generated using battalion-training scenarios for Southwest Asia operations and OMS/MP (Operations Mission Summary / Mission Profile) movement rates as provided by the U.S. Army Armor Center at Fort Knox, Kentucky. The input file indicates the time each message occurs, where it is received and who or what equipment receives it, and the subsequent routing and task flow initiated by this message. Tasks performed in response to these messages come from an external source (usually a radio, digital link, or coworker), and are labeled "reactive", and either "voice" or "digital". In addition to external messages, the scenario file also contains "internal information messages" that are mental "triggers" for personnel to periodically perform "proactive" (self-initiated) tasks that are an essential part of C2 operations and workstation database manipulation (Knapp, Johnson, Barnette, Wojciechowski, Kilduff, and Swoboda, 1997a). Examples of these proactive tasks are situation assessment checks, updating documentation (plans, orders, etc.), preparing status reports, and calling up windows of information for review.

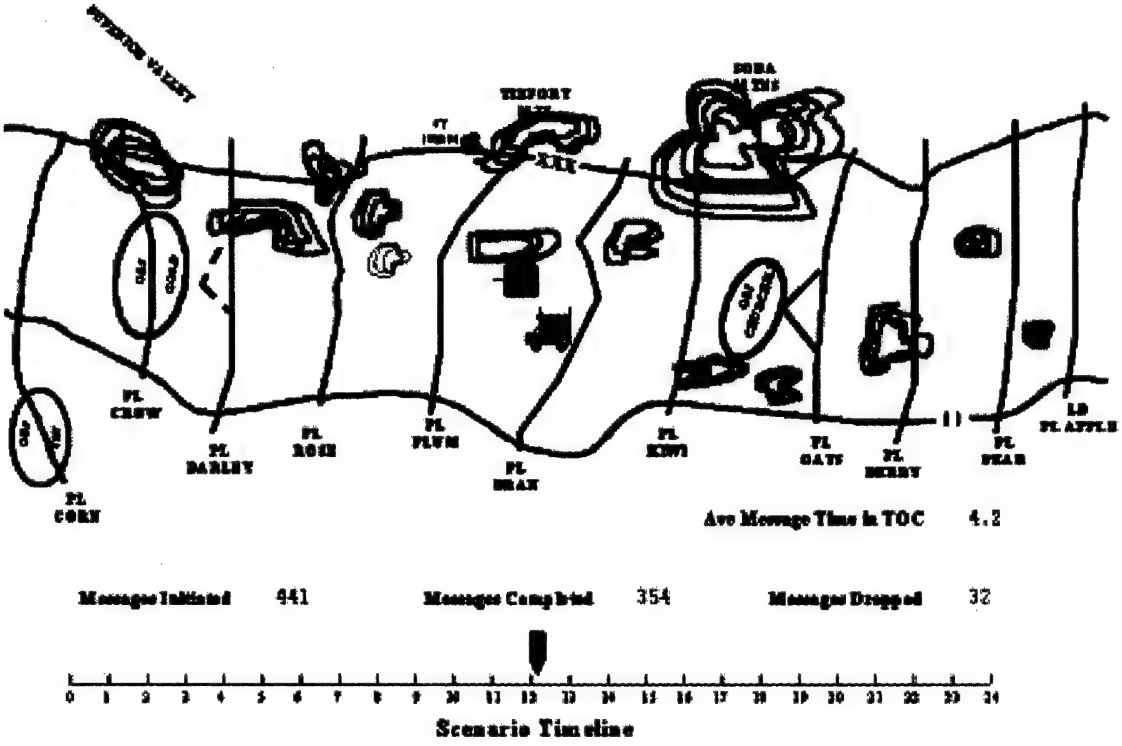

Figure 3 – Tactical Scenario Overlay
(Middlebrooks et al., 1999)

2.3. The CoHOST Computer Model.

Computer modelers used the discrete event programming language MicroSaint™ which provided software protocols and conventions to input the tasks, task sequences, flow logic, and task timing and workload data from the network diagrams into an executable model. The computer model works according to a basic "input-throughput-output" scheme as shown in Figure 4. That is, the inputs to the model are message events from the scenario input file, which present an information event stream in a time sequence synchronized to mission activity phases. As these information events enter the model, tasks are triggered and performed in a pattern that reflects the logic for task branching, interrupt priorities, time outs, and collaborative (interactive) tasks. Any information event that triggers a staff huddle always has the highest priority (Knapp et al., 1997a).

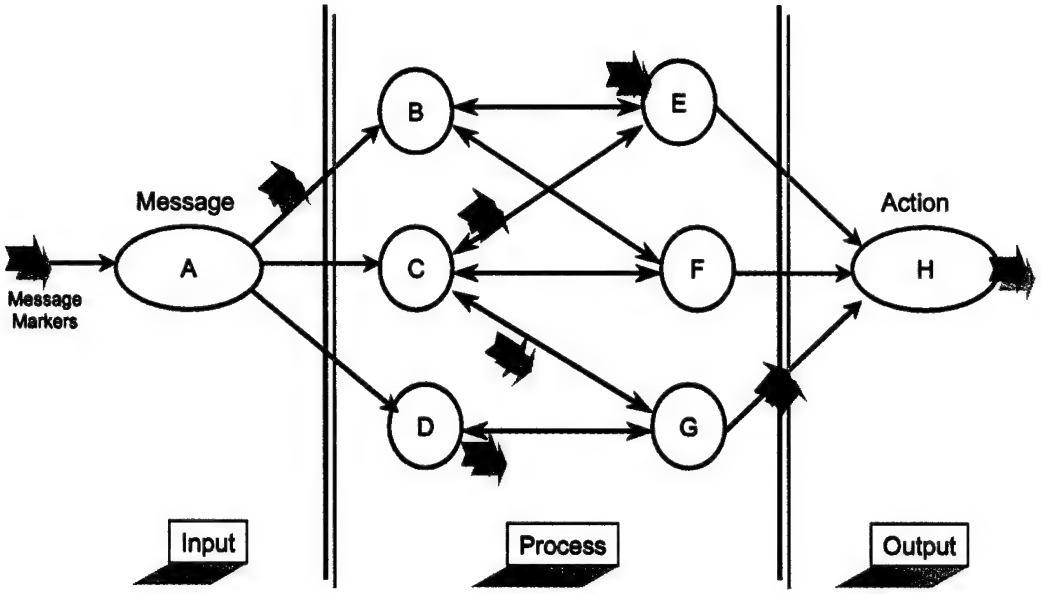

Figure 4 – Conceptual Model of TOC Operations
(Middlebrooks et al., 1999)

The model runs on an IBM-compatible PC running Windows 95 (or higher). During model execution, a graphical user interface (GUI) screen displays the progress of tasks being performed by each C2 section and individual soldier position, as information messages enter the system. Bar and pie charts on the GUI display allow an observer to get an initial look at whether staff sections and individuals are keeping pace or falling behind in their information processing, as well as how busy or idle they are as scenario time goes on. A screen print from this real-time display is shown in Figure 5.

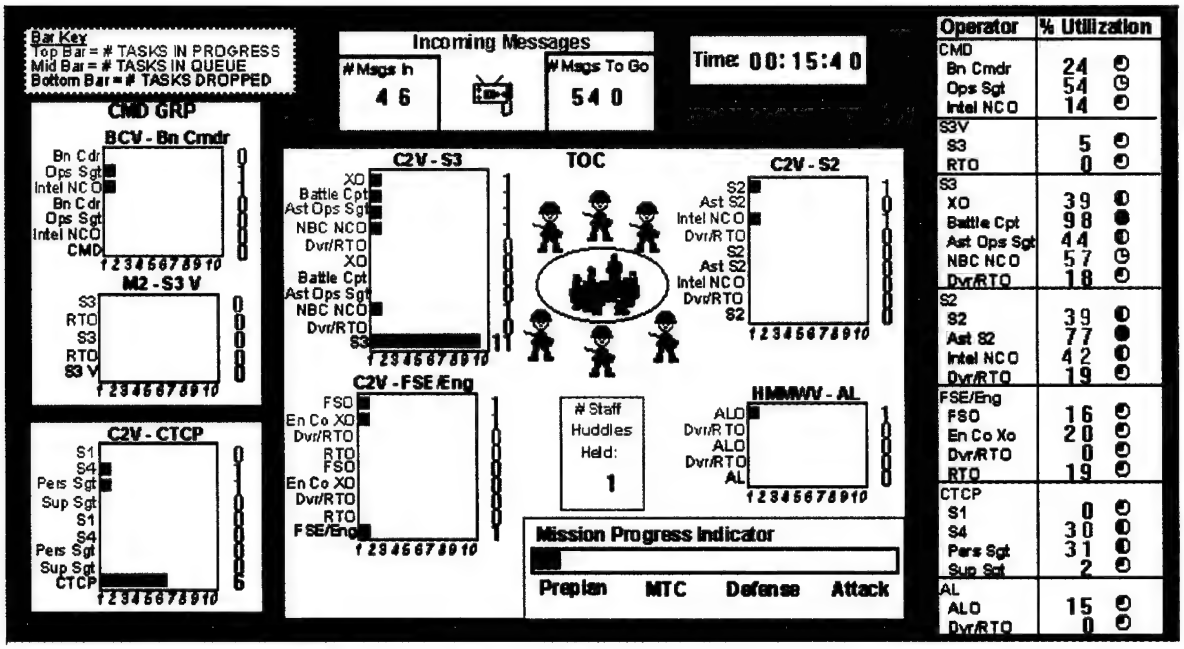

Figure 5 – CoHOST Model Action View Display
(Middlebrooks et al., 1999)

The model was developed in three steps that occurred iteratively and in parallel:

(1) Cognitive task analysis and workload measurement for battalion command and control tasks, using techniques from the most recent human performance and related literature;

(2) Obtaining and translating scenarios and task flow data from pertinent documentation and battalion command and control subject matter experts;

(3) Exercising the MicroSaint™ discrete event simulation programming language to simulate the task and flow data from steps one and two. Following data input, the C2 computer model was debugged and executed, and the resulting output data were analyzed using descriptive and comparative statistics. An example of the task flow logic contained in one of the CoHOST models is shown in Figure 6.

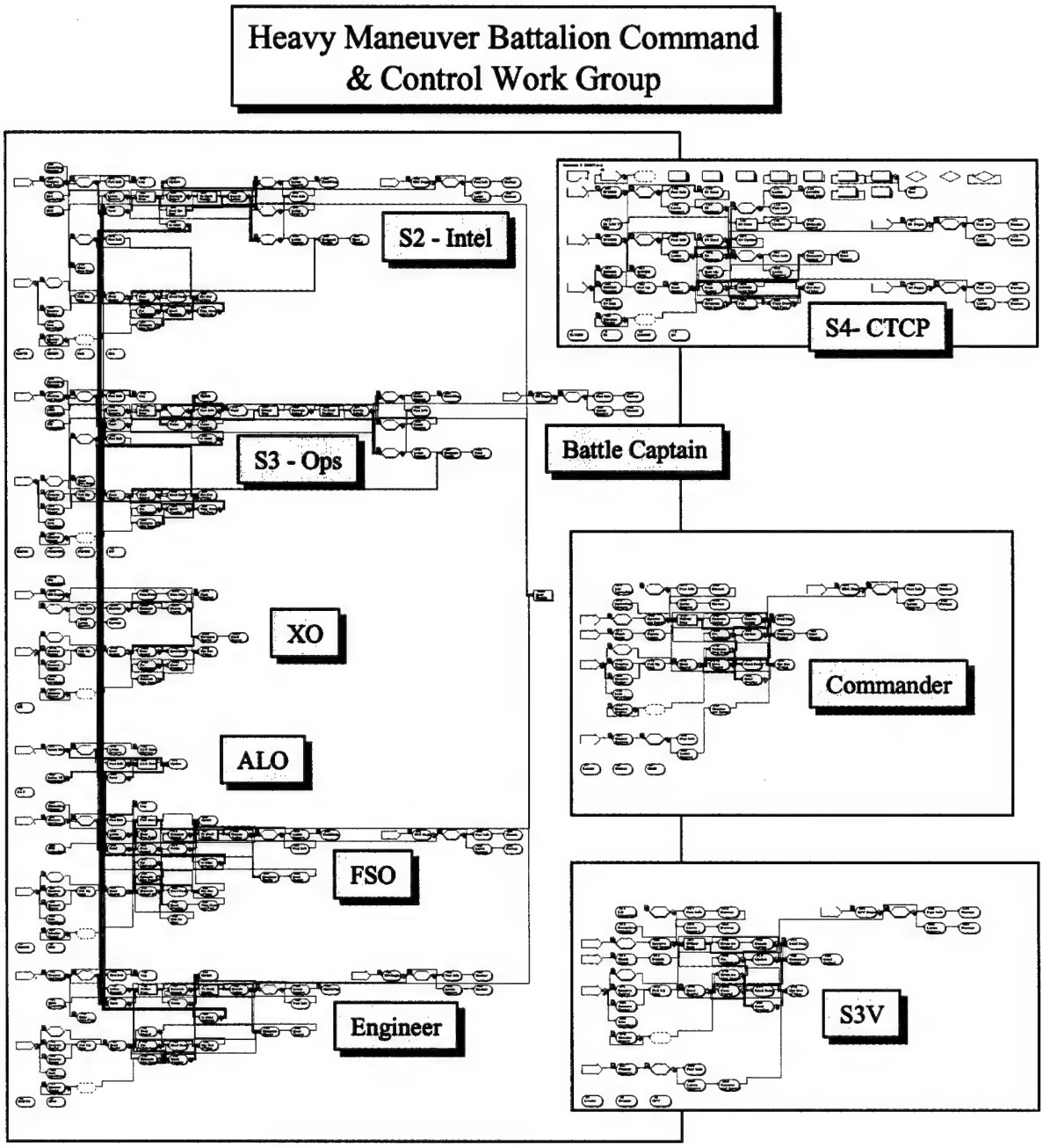

Figure 6 – CoHOST Model Network Flow Diagram

2.4. Results From Original CoHOST Project.

Each CoHOST model was executed using communication messages from the tactical scenario as driver events for the simulation. The dependent measures that were evaluated were:

1) Tasks dropped – those tasks that an operator did not complete for any reason.

2) Tasks interrupted – those tasks whose performance was interrupted by another task or event of higher priority.

3) Number of task queues generated – the number of times an incoming task was assigned to a queue wait state because the operator identified to perform the task was busy performing another task of equal or higher priority.

4) Task backlog work – off time – the amount of time it took for an operator to eliminate the tasks that were queued up for execution.

Additional analyses were performed to assess the reasons for and types of information flow bottlenecks. The purpose of this review was to identify why tasks got dropped, queued, and/ or interrupted.

Initially, three CoHOST models were executed with varying configurations of organizational configuration and implementation of digital communications equipment. The results are summarized in Figure 7.

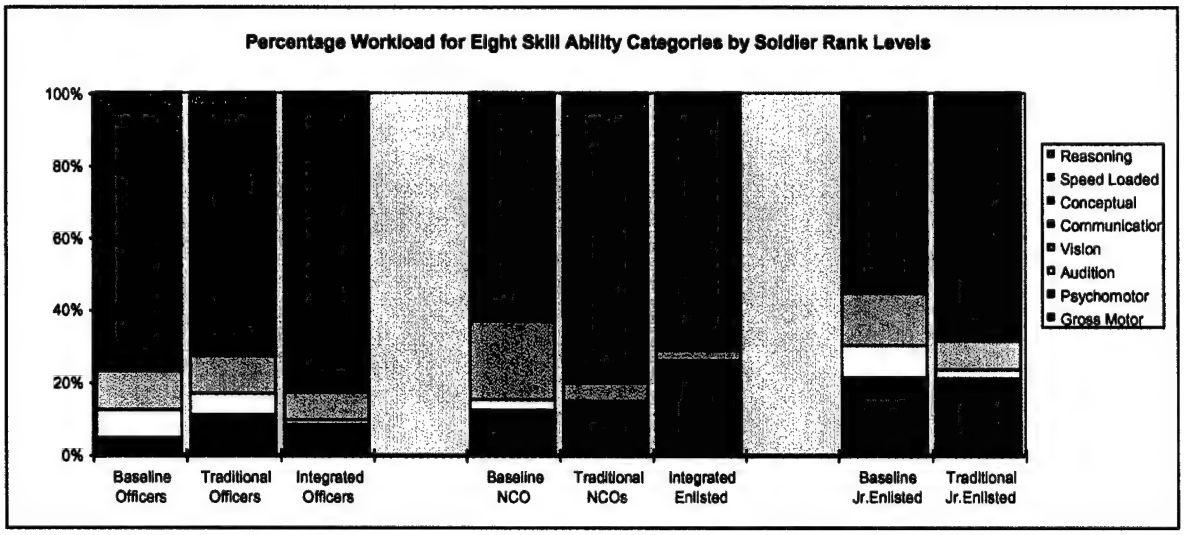

Figure 7 – Percent of Time Spent In Each Performance Category of the Taxonomy (Knapp et al., 1997c)

Figure 7 presents results from the three runs with information organized according to the taxonomy. The 3 groups of bars represent information from officers, NCO's and junior enlisted personnel. The 3 bars within each group represent the data from each run. The three runs were identified as:

1) Baseline Model – Personnel and equipment configuration according to the then (1996) mode of TOC operation with analog communications equipment (Knapp et al., 1997a).

2) Traditional Model – Same as the baseline model but with first generation digital communications equipment (Knapp, Johnson, Barnette, Wojciechowski, Kilduff, and Swoboda, 1997b).

3) Integrated Model – Reorganized personnel organizational structure to capitalize on enhanced communications equipment capabilities and objective digital communications equipment (Knapp et al., 1997c).

There was no data for the junior enlisted for the Integrated model run because all the junior enlisted personnel were eliminated by the personnel reorganization for that model run.

The sections of each bar graph are color coded to correspond to the eight categories of the taxonomy as indicated in the legend. The top category represented the amount of time spent performing the proactive think – ahead reasoning cognitive tasks that are critically important for situation analysis and decision making abilities. The next category is the cognitive speed loaded category that is indicative of activity that requires immediate attention for quick servicing of the activity before the content of the activity becomes obsolete. Looking at the three bar graphs for the 3 model runs for the officers at the left side of Figure 7, it can be seen that in the baseline model the officers were modeled as being able to spend about 10% of their time performing the proactive think – ahead tasks necessary to maintain cognitive awareness of the battlefield and develop decisions on what actions to take next. Subject Matter Expert opinion validated that this estimate roughly corresponded to the circumstances of actual battle. The middle bar from the traditional model run that simulated first generation digital communications equipment for the officers show that this activity was greatly reduced being almost totally supplanted by the speed loaded activity of the next taxonomic category. The third run from the integrated model that simulated the full capabilities of digital communications equipment being developed and a reorganization of personnel to take full advantage of it shows an even worse situation with almost all reasoning activity disappeared.

The explanation for this phenomenon comes from a realization that while each element of the communications equipment was performing exactly as it was designed, the design was based on maximizing hardware system performance that did not include the human as an integral component of the system. The result was that increased message arrival rates coming from enhanced communications systems were forcing the decision makers to focus their attention to just trying to keep up with and react to the messages with the result that there was no time left to analyze and interpret the information they were receiving. Thus, in this series of simulation runs

the officer decision makers went from a pseudo proactive think – ahead reasoning mode to an almost total reactive speed loaded mode while trying to keep up with the increased message traffic. A contributing element to this situation was the elimination of the junior enlisted personnel whose primary duties were to function as equipment operators. With the limited space and seating in the C2V the officer decision makers were required to sit at and operate their own communications consoles and had to personally interact with the incoming message traffic.

2.5. Summary of Original CoHOST Project.

By looking at which individuals were predicted to be workload saturated for each model run condition, a project conclusion was reached that increasing automation does not necessarily improve human decision making performance and may, in fact, degrade it.

3. Method.

An experimental design is developed that is an extension of a basic 2^5 ¼ replicate fractional factorial design that includes an additional level to allow an examination of the quadratic components of the main effects. This design is further optimized by unbalancing the treatment orders to allow the computer simulation requirements to stay within acceptable limits and still provide enough data to support the desired analysis.

3.1. Experimental Design.

The purpose of this effort is to conduct an experiment to evaluate work environment conditions to achieve optimum human performance. The work environment is a battalion level command and control center for the U.S. Army during combat operations and is modeled by the CoHOST battle simulation. The CoHOST simulation models 17 different individuals in the command center. This analysis focuses on one of these operators, the Battalion Commander. The independent variables will be five types of tasks that personnel perform in this situation. The dependent variables will be the resulting workload and total utilization as determined from the performance of the specified job tasks by the simulated human operators during the computer run. Additional dependent variables will assess the number of tasks that become queued, dropped, or interrupted during the course of the simulation.

Although early limitations inherent in using computer simulations to support experimental designs (Smith and Mauro, 1981) have largely been overcome due to technical advances in hardware and software, the temptation to use the computer to investigate experimental design configurations that would be impossible with controlled experimentation using human test subjects can lead to complex and large experimental efforts. As a result, many of Smith and Mauro's ideas that stemmed from the batch processing orientation processing capabilities of the 1980's still have meaning in the high speed PC and Workstation technological base of today. Their thoughts on ways to reduce the number of factors and required number of computer runs still have meaning where desired input conditions and outcomes must be balanced against the ability to produce those outcomes in a timely manner. The simulation support plan as presented in the following paragraph will be iterated throughout this paper to arrive at an optimum mix of computer support requirements versus desired experimental outcomes.

As a first step, the base required level of computer simulation support needs to be identified. A CoHOST simulation run of one replication takes approximately 10 minutes to process a 24 hour battlefield scenario on the available hardware (see paragraph 3.2.1). Previous test runs of the simulation have determined that each data gathering run needs to include 15 replications of the simulation to provide a 95% probability of achieving satisfactory error levels of the dependent variables due to random number generation in the model. Further, in order to simulate, for example, the effects of 3 subjects for each treatment condition the experiment must be executed three times at each treatment level with the random number seed set to a new value at the beginning of each run. Thus, the anticipated required number of computer simulation run replications to satisfy this requirement is 32 x 15 x 3 = 1440. At 10 minutes per run replication this requires 1440 x 10 = 14,400 minutes or 240 hours of computer time. In order to bring this required processing time down to a manageable level a ¼ replicate fractional factorial of the 2^5 within subjects design (n=3) will be used. With this design 60 hours of computer time is still required to produce 360 replications with the available hardware and software.

3.1.1. Independent Variables.

The experimental design for this study includes five independent variables (IV). These IV's are listed in Table 1 and comprise the five major categories of performance evaluation that the CoHOST model uses to evaluate task load performance. In the CoHOST model these performance categories are decomposed into 32 task performance categories to provide the level of detail that the developers of the simulation were seeking. These 32 performance categories and their mapping to the higher level categories is shown in Figure 8. When this experimental design was being developed the choice was to evaluate all 32 tasks as independent variables or to use their aggregated values in the five top level categories. The original model developers set up these top level categories to gather knowledge, skill and ability data from subject matter experts according to the human performance taxonomy used by the simulation (Fleishman and Quaintance, 1984). As the evaluation of a 2^5 full factorial design was deemed impractical due to limitations on computer resources and time constraints forcing a more efficient ¼ replicate design, an attempt to evaluate a 2^{32} design was beyond the capabilities of this effort. Although the ¼ replicate fractional factorial 2^5 design allows a resolution III experiment that is able to resolve all the main effects, trying to bring a 2^{32} design into a manageable scope with a 1/8 or 1/16 fractional factorial design would not allow a full resolution III evaluation. For these

reasons, an experimental design utilizing the 5 top level factors was chosen even though it required manual translation of data into and out of the 32 task categories used by the simulation.

Communicate and Report	01-Receive and Record/Analog
Communicate and Report	02-Pass Information
Communicate and Report	03-Listen-Receive Information
Communicate and Report	04-Secondary Monitor
Communicate and Report	05-Log Message
Communicate and Report	06-Route (Outside the Section)
Communicate and Report	07-Send Message
Communicate and Report	08-Verbal Order
Communicate and Report	09-Roll Up Reports
Communicate and Report	10-Call to Conference
Communicate and Report	26-Receive Digital Message
Communicate and Report	27-Input data Into Computer
Communicate and Report	28-Send Digital Information
Decide and Recommend / Direct	11-Decide Action
Decide and Recommend / Direct	12-Decide
Decide and Recommend / Direct	13-Recommend Action
Evaluate and Estimate Impact	14-Estimate Impact
Evaluate and Estimate Impact	15-Data Gathering/ Analog
Evaluate and Estimate Impact	16-Find Options
Evaluate and Estimate Impact	17-Compare Alternatives
Evaluate and Estimate Impact	18-Discuss
Evaluate and Estimate Impact	29-Data Gathering/ Digital
Identify/Understand Situational Picture	19-Read/Analog
Identify/Understand Situational Picture	20-Scan
Identify/Understand Situational Picture	21-Update/ Analog
Identify/Understand Situational Picture	22-Check Status
Identify/Understand Situational Picture	23-Problem Definition
Identify/Understand Situational Picture	24-Listen/Monitor - Analog
Identify/Understand Situational Picture	30-Read/ Digital
Identify/Understand Situational Picture	31-Scan Digital
Identify/Understand Situational Picture	32-Monitor Digital
Manage Resources	25-Manage Resources

Figure 8 – CoHOST Task Performance Categories

The first IV is Communicating and Reporting Tasks (CAR). This variable assesses the ability of the operator to express himself or herself through both auditory and automated means of communication. The next variable is Deciding and Recommending or Directing Tasks (DRD). The DRD variable measures the performance load on the operator from making decisions and in passing the results of those decisions to superiors in the form of

recommendations or to subordinates in the form of directives or orders. The variable Evaluating and Estimating Impact (EEI) measures the primarily cognitive activities associated with the assessment of what the results of actions taken and directives issued by the operator will be.

The task Identify and Understand Situational Picture (USP) describes those tasks and activities associated with the assessment of the activities going on around the operator and the primarily cognitive activities of trying to understand the relevance of these activities and in the development and maintenance of a mental model that reflects all the activities that are going on around the operator that is of significance.

The Manage Resources (MRS) variable requires an extended description. When the CoHOST simulation was being developed this was a variable element that was designed to track the operator's ability to manage the available physical resources and how the presence or absence of these resources enabled the operator to perform his or her duties. However, this capability was never implemented in the simulation model. Although the data elements and variable tables were coded into the simulation, no logic was ever implemented to use these variables. When the experimental design for this study was being developed it was decided to use this variable in the design to determine baseline values to establish a threshold of significance for the lack of fit (LOF) calculation. By using the MRS variable to establish the significance level for LOF for interpreting results from regression runs with the SAS statistical package, actual values for significance can be mathematically determined that take into account the random variability 'noise' in the CoHOST model. This process consists of recording the 'p' value from the SAS run for the MRS variable and then selecting the next highest value that is available in standard statistical tables (Winer, Brown, and Michels, 1991) which is then used in a manually evaluated decision rule evaluation of the significance of the LOF parameter. After its use for determining this threshold of significance, the MRS variable is then dropped from all further analyses in this study.

The treatment levels for the experimental design are set up by adjusting up and down the original values in the CoHOST model that are used to determine the values for each of the IV's as shown in Table 1. The amount of adjustment up and down for the baseline values was arbitrarily determined to be 20% which was judged to provide two data points approximately equally distanced on a 100% scale. As only the battalion commander operator is being evaluated

in this study, the performance values for these five categories as they apply to this operator are used to set up these treatments.

Table 1 – Independent Variables and Their Treatment Levels

Independent Variables	Treatment Level
Communicate and Report Tasks (CAR)	(Baseline – 20%, Baseline +20%)
Decide and Recommend / Direct Tasks (DRD)	(Baseline – 20%, Baseline +20%)
Evaluate and Estimate Impact Tasks (EEI)	(Baseline – 20%, Baseline +20%)
Identify/Understand Situational Picture Tasks (USP)	(Baseline – 20%, Baseline +20%)
Manage Resources Tasks (MRS)	(Baseline – 20%, Baseline +20%)

3.1.2. Description of ¼ Replicate Fractional Factorial Design.

A full factorial 2^5 design would provide 32 treatment combinations, therefore this ¼ replicate design provides 8 treatment combinations. Figure 9 shows the SAS ADX Experiment Design module specifying a 2 level, 5 factor design that generates 8 treatment combinations. This indicates that a Resolution 3 design is possible at the ¼ fractional factorial level with only the main effects being estimable. However, this thesis is only interested in evaluating the main effects due to the nature of the factors involved. All of the higher interactions, including the two way interactions, have no meaning for this analysis. For example, an attempt to interpret the interaction between "Communicating and Reporting" and "Evaluating and Estimating Impact" would presuppose individual actions that are not quantifiable in the TOC based work situation. For this reason only the main factor effects are of interest. This further justifies a Resolution level 3 experiment which can be conducted at the ¼ fractional factorial level.

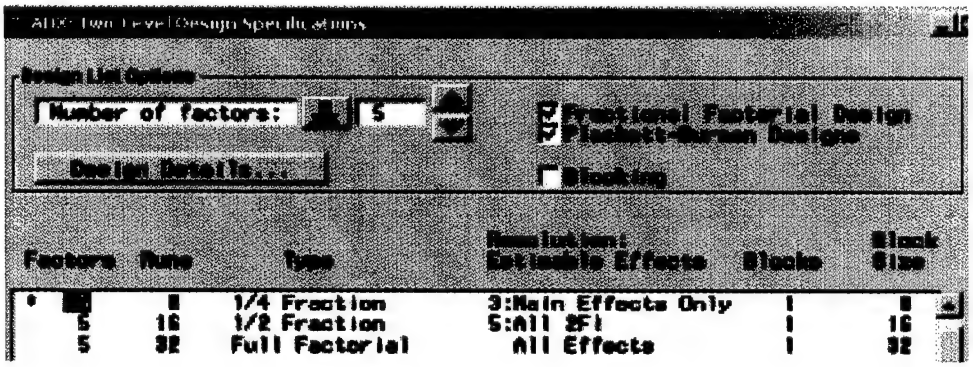

Figure 9 – Configuration Options for a 5 Factor Experimental Design

The treatment combinations for this design are shown in Table 2. See Appendix A for the derivation of these combinations.

Table 2 – ¼ Replicate Treatment Combinations

		Comm & Report	Decide & Recommend / Direct	Evaluate & Estimate Impact	Identify / Understand Situational Picture	Manage Resources
Treatment	Factor:	A	B	C	D	E
Combinations		CAR	DRD	EEI	USP	MRS
1		1	-1	-1	-1	-1
2		-1	1	1	-1	-1
3		1	1	-1	1	-1
4		-1	-1	1	1	-1
5		-1	1	-1	-1	1
6		1	-1	1	-1	1
7		-1	-1	-1	1	1
8		1	1	1	1	1

3.1.3. ¼ Replicate Identity Relationships.

Using the experimental design capabilities in SAS the confounding rules were identified and are shown in Figure 10.

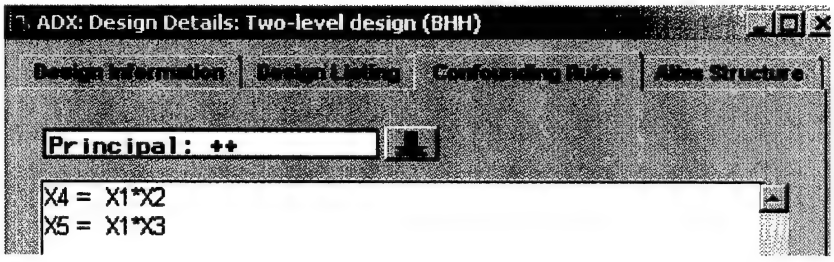

Figure 10 – ¼ Replicate Confounding Rules

From this the identity relationships are determined and are shown at Equation 1.

C1:	X1 + X2 + X4 = 0	(Mod. 2)
C2:	X1 + X3 + X5 = 0	(Mod. 2)
C1+C2:	X2 + X3 + X4 + X5 = 0	(Mod. 2)

Equation 1 – Identity Relationships: 2^5 – ¼ Replicate Fractional Factorial Design

Applying these identity relationships to all of the main effects and interactions, the ANOVA Summary Table for this design is shown in Table 3.

Table 3 – ANOVA Summary Table for ¼ Replicate Fractional Factorial Design

	C1: X1 + X2 + X4 =	AxBxD
	C2: X1 + X3 + X5 =	AxCxE
	C1+C2: X2 + X3 + X4 + X5 =	BxCxDxE
	I = AxBxD, AxCxE, BxCxDxE	
	n =	5
	Treatments =	8
Source		df
A	(BxD, CxE, AxBxCxDxE)	1
B	(AxD, AxBxCxE, CxDxE)	1
C	(AxBxCxD, AxE, BxDxE)	1
D	(AxB, AxCxDxE, BxCxE)	1
E	(AxBxDxE, AxC, BxCxD)	1
BxC	(AxCxD, AxBxE, DxE)	1
BxE	(AxDxE, AxBxC, CxD)	1
Subj / Treatments =	Treatments x (n-1)	32
	Total:	39
Verification:	Treatments x n -1	39

3.1.4. Augmenting The ¼ Replicate Fractional Factorial Design.

The experimental design as shown in Table 3 provides an economical means of determining the linear components of the main effects of the independent variables. However, it does not provide any indication of whether or not the simulation model is generating any significant higher order components of these effects because of the fact that the 2^5 - ¼ replicate fractional factorial design is only capable of generating a linear response surface. Traditionally, to evaluate if higher order effects exist in the model would require an expansion of the model to 3 or more levels per treatment condition along with a full factorial evaluation of the results. Because of limitations already discussed this is not possible using traditional factorial designs.

There is the possibility, however, to investigate possible quadratic effects in the model which could provide the justification for sequential experimentation into a higher order model. This possibility is to augment the existing number of treatment conditions with one additional condition by using the center point of the data as shown in Table 4.

Table 4 – Augmentation of ¼ Replicate Treatment Combinations

		Comm & Report	Decide & Recommend / Direct	Evaluate & Estimate Impact	Identify / Understand Situational Picture	Manage Resources
Treatment	Factor:	A	B	C	D	E
Combinations		CAR	DRD	EEI	USP	MRS
1		1	-1	-1	-1	-1
2		-1	1	1	-1	-1
3		1	1	-1	1	-1
4		-1	-1	1	1	-1
5		-1	1	-1	-1	1
6		1	-1	1	-1	1
7		-1	-1	-1	1	1
8		1	1	1	1	1
9		0	0	0	0	0

Since the treatment levels for this model design were determined by adding and subtracting 20% to the original observed data for the model as described in Paragraph 2.2.2, the center points for these +1/-1 treatment levels exist in the original data. By designating these data as treatment level '0' a ninth treatment condition can be added to the fractional factorial design as an augmented treatment condition with all the independent variables at a treatment level of '0'. This will provide the means to investigate whether any quadratic components exist for the main effects in the empirical model.

3.1.5. Dependent Variables.

In the CoHOST model these five parameters are not just individual numbers but consist of products of the amount of time required to perform tasks for each category and the KSA values describing the physical and mental level of effort required to perform the tasks. The dependent variables (DV) for the experimental design correspond to those major categories of

data programmed into the CoHOST model. The first dependent variable is Taskload. Originally termed workload by the model developers, this term refers to the amount of physical and mental performance imposed on the operator by the tasks being performed. This experimental design includes two measures of taskload.

The seven dependent variables are summarized in Table 5. The first taskload measure is Taskload from Knowledge, Skills, and Abilities (TLKSA). The treatment levels for this DV are established by applying the 20% adjustment factor to the KSA values from the performance taxonomy in the CoHOST database. As the KSA values are only used in the taskload calculation and none of the other output parameters, the model runs conducted with these adjustments provide an operator response to the effects to more or less mental and physical effort expended on the performance of the tasks.

Table 5 – Dependent Variables

Dependent Variables	Description
Taskload/ KSA (TLKSA)	Expressed as a dimensionless quantity that is an expression representing the performance of individual tasks with specified skill levels over time.
Taskload/ TT (TLTT)	Expressed as a dimensionless quantity that is an expression representing the performance of individual tasks when the amount of time to perform that task is varied.
Utilization (UTIL)	Percent of time the operator was busy over the simulation run.
Tasks Queued (NOQUE)	Number of tasks that were queued on the operator
Tasks Dropped (TSKDRP)	Number of tasks that the operator dropped during the simulation.
Tasks Suspended (TSKSUP)	Number of tasks that were suspended during a run as a result of a higher priority interrupt.
Tasks Interrupted (TSKINT)	Number of times the operator was interrupted while performing a task.

The second taskload measure is Taskload from Task Time (TLTT). The treatment levels for this DV are established by applying the 20% adjustment factor to the amount of time, in seconds, required to perform each task in the CoHOST database. The model runs conducted with these adjustments provide an operator response to the effects of more or less time required to perform each task. As the task time parameter is also used in all the other CoHOST output categories, the computer runs made with these treatment combinations also provided data for the remaining DV's. These remaining DV's are Utilization (UTIL), Number of Tasks Queued on The Operator during the simulation run (NOQUE), the Number of Tasks Dropped (TSKDRP) by the operator during the run (i.e., not completed for any reason), the Number of Tasks Suspended (TSKSUP) during the run, and the Number of Tasks that were Interrupted (TSKINT) during the run. While the CoHOST model simulates the activities of 23 operators in the command and control center, each of these dependent measures describe activities for the single operator under investigation in this thesis which is the battalion commander.

3.2. Experimental Procedures.

The first step in collecting data with this or any other computer model is to determine how many replications of the simulation must be made in each computer run in order to account for random variability in the simulation. The simulation is then executed according to the experimental design using the number of required replications and data is collected.

3.2.1. Determination Of Simulation Replication Count.

With stochastic computer simulations, multiple runs must be conducted for each combination of the independent variables in order to account for the variability induced by the random number generation (Whicker and Sigelman, 1991a). When analysis is conducted on data generated by a simulation due to random effects then the variance of the output data must be controlled so that it falls within a desired precision limit (Banks et al., 1996). Stated succinctly, a computer simulation model involving Monte Carlo determinations needs to be repeated or 'replicated' as many times as necessary to get the required precision (Kelton, 1995). This can be achieved by making multiple replications of the simulation runs by holding the independent variable levels constant and changing the random number seed at the start of each replication run. When a sufficient number of replications have been executed then the mean of the output data from the replications can be expected to fall within the desired confidence limit. For this

study it is desired to have the output data from the simulation exhibit a 95% probability of falling within the confidence limit which gives a specified error level, ε, equal to ±.05 of the mean. Following Banks' procedures, (pages 429-449), the required number of replications can be determined that needs to be conducted to support the intended analysis.

An initial simulation run of 5 replications was made with a starting random number seed of 1. The model automatically used the next random number at the end of each replication as the starting seed for the next replication. The resulting data for workload, utilization, tasks queued, tasks dropped, and tasks interrupted for the Battalion Commander is shown in Table 6. A replication analysis was performed for each of these dependent variables to determine the number of replications required to satisfy each of these measures.

Table 6 – Data From Initial 5 Replication Simulation Run

Battalion Commander	Workload (*Util)	Utilization (*Util)	Number of Queues (*Opdata)	Tasks Interrupted (*Opdata)	Tasks Suspended (*Opdata)	Tasks Dropped (*Opdata)
Replication 1	3561179.34	92.30%	50	90	11	11
Replication 2	3549435.31	92.07%	48	90	11	13
Replication 3	3556732.44	92.39%	54	90	10	11
Replication 4	3548795.69	93.21%	52	88	11	9
Replication 5	3526501.95	91.95%	51	91	11	13
Mean	3548528.95	92.38%	51.00	89.80	10.80	11.40
Standard Deviation	13354.88	0.0049	2.24	1.10	0.45	1.67
5% Error Limit = .05, relative to the mean	177426.45	0.0462	2.55	4.49	0.54	0.57
* (filename) == name of model output data file						

The desire is to determine the number of replications required so that the relative error (relative to the mean) for any of the dependent variables does not exceed 5 percent. The iterative formula to determine the number of replications is (Banks et al., 1996) (eq. 12.29, p. 449) is shown as Equation 2.

$$R \geq \left(\frac{Z_{\frac{\alpha}{2}} S_0}{\varepsilon} \right)^2$$

Equation 2 – Initial Estimate for Number of Required Replications, R

where,

R	≡	number of replications required to achieve the desired error level
Z	≡	Z statistic
S_0	≡	Standard Deviation of the computed parameter across the simulation replications
ε	≡	Error Level Threshold
α	≡	Percent Error Level of the mean value of the computed parameter across the simulation replications.

This expression is iteratively computed with the value of the computed replications being substituted for R until the value for R satisfies the greater than or equal to condition at which time the value for R becomes the required number of replications necessary to compensate for the random effects of the simulation.

Example Calculation For Replication Analysis For Workload Parameter:

From Table 6:

$S_0 = 1354.88$

$\varepsilon = 117426.45$

$\alpha = .05$; $\alpha/2 = .025$; $1-\alpha/2 = .975$

$\therefore Z_{.975} = 1.96$, from Z table, page 966 (Winer et al., 1991)

Thus,

$R \geq \{(Z_{\alpha/2} \times S_0) / \varepsilon\}^2$

$R \geq \{(1.96 \times 13354.88) / 177426.45\}^2 = .02176 \approx 1$

So, use R = 1. Since this is less than 50, use the *t* distribution, plug back into the formula and evaluate. From the *t* table, (Winer et al., 1991), page 967, $t_{\alpha/2,1} = 12.71$

$$R \geq \{(t_{97.5,2} \times S_0) / \varepsilon\}^2$$

$$R \geq \{(12.71 \times 13354.88) / 177426.45\}^2 = .91524 \approx 1$$

$\therefore 5 \geq 1$ relationship is verified. As 1 run is required and 5 have been made, no additional runs are required to satisfy this parameter.

Table 7 shows the replication analysis for all the dependent variables. From this analysis it is determined that the parameter "Number of Queues" is the defining variable and will require 15 replication runs to satisfy the criteria.

Table 7 – Replication Analysis For Initial 5 Replication Run

$R \geq [(Z_{\alpha/2} \times S_0) / \varepsilon]^2$							
Battalion Commander	$Z_{\alpha/2}$	$t_{\alpha/2,df}$	S_0	ε	R	R Adjusted	Conclusion
Workload:							
	$Z_{.975}$	$t_{97.5,1}$	S_0	ε	R	R Adjusted	
	1.96		13354.88	177426.45	0.02176	1	Since R < 50, use t disbribution and recalculate
		12.71	13354.88	177426.45	0.91524	1	$\therefore 5 \geq 1$ relationship is satisfied. No more runs required
Utilization:							
	$Z_{.975}$	$t_{97.5,1}$	S_0	ε	R	R Adjusted	
	1.96		0.0049	0.0462	0.04395	1	Since R < 50, use t disbribution and recalculate
		12.71	0.0049	0.0462	1.84795	2	$\therefore 5 \geq 2$ relationship is satisfied. No more runs required
Number of Queues							
	$Z_{.975}$		S_0	ε	R	R Adjusted	
	1.96	$t_{97.5,2}$	2.24	2.55	2.95394	3	Since R < 50, use t disbribution and recalculate
		4.3	2.24	2.55	14.21761	15	$\therefore 5 \geq 15$ -> No; Set R=15 and reevaluate
		$t_{97.5,14}$	S_0	ε	R		
		2.14	2.24	2.55	3.52141	4	**$\therefore 15 \geq 4$ -> Yes, therefore Use R = 15**
Tasks Interrupted							
	$Z_{.975}$		S_0	ε	R	R Adjusted	
	1.96	$t_{97.5,1}$	1.10	4.49	0.22867	1	Since R < 50, use t disbribution and recalculate
		12.71	1.10	4.49	9.61567	10	$\therefore 5 \geq 10$ -> No; Set R=10 and reevaluate
		$t_{97.5,9}$	S_0	ε	R		
		2.26	1.10	4.49	0.30402	1	**$\therefore 10 \geq 1$ -> Yes, therefore Use R = 10**
Tasks Suspended							
	$Z_{.975}$		S_0	ε	R	R Adjusted	
	1.96	$t_{97.5,2}$	0.45	0.54	2.63484	3	Since R < 50, use t disbribution and recalculate
		4.3	0.45	0.54	12.68176	13	$\therefore 5 \geq 13$ -> No; Set R=13 and reevaluate
		$t_{97.5,12}$	S_0	ε	R		
		2.18	0.45	0.54	3.25953	4	**$\therefore 13 \geq 4$ -> Yes, therefore Use R = 13**

3.2.2. Simulation Execution.

Because MicroSaint™ simulations have the input data embedded in the model code, a separate simulation model was configured for each simulation run. Each simulation run of 15 replications was conducted with the copy of the model that was configured for the treatment condition associated with the run. A total of 9 models was configured for the 9 treatment conditions for each of two treatment manipulations. The dependent variable "Taskload from Knowledge, Skills and Abilities (TLKSA)" was developed by adjusting the behaviorally anchored taxon values for each performance task from Fleishman's taxonomy (Fleishman and Quaintance, 1984). These adjustments consisted of adding and subtracting 20% to the base values already existing in the simulation in order to set up two treatment conditions according to the experimental design. An excerpt from the spreadsheet used to set up these parameters is in Table 8. The Duty Name indicates parameters for the first independent variable, Communicate and Report (CAR). The Scale Number column indicates taxon #1 from the 50 elements of Fleishman's taxonomy. The Scale Name is the associated name for the Scale Number. The Detail Duty represents those task duties that the Battalion Commander performs in the model while conducting the oral comprehension component of communicating and reporting. The Detail Score column is the original KSA performance score according to the 7 point behaviorally anchored scale for that performance task. The Treatment Factor is the adjustment factor for the experimental design here showing an increase of 20% for the +1 treatment level. Finally, the Detail Score-Adj column shows the adjusted task score as a multiple of the Detail Score and the Treatment Factor. A modified spreadsheet was then configured with the Detail Score-Adj value replacing the Detail Score column that was then processed with an Excel macro to generate the MicroSaint™ compatible code statements which were then inserted into the simulation model in the WL_CMD (JASS Workload Data) function table.

Table 8 – Excerpt of Input Data For Configuration of KSA Treatment Levels

Communicate and Report	0010	ORAL COMPREHENSION	01-Receive and Record/Analog	1.84	1.20	2.21
Communicate and Report	0010	ORAL COMPREHENSION	02-Pass Information	0.00	1.20	0.00
Communicate and Report	0010	ORAL COMPREHENSION	03-Listen-Receive Information	1.84	1.20	2.21
Communicate and Report	0010	ORAL COMPREHENSION	04-Secondary Monitor	1.84	1.20	2.21
Communicate and Report	0010	ORAL COMPREHENSION	05-Log Message	0.00	1.20	0.00
Communicate and Report	0010	ORAL COMPREHENSION	06-Route (Outside the Section)	0.00	1.20	0.00
Communicate and Report	0010	ORAL COMPREHENSION	07-Send Message	0.00	1.20	0.00
Communicate and Report	0010	ORAL COMPREHENSION	08-Verbal Order	1.84	1.20	2.21
Communicate and Report	0010	ORAL COMPREHENSION	09-Roll Up Reports	0.00	1.20	0.00
Communicate and Report	0010	ORAL COMPREHENSION	10-Call to Conference	1.84	1.20	2.21
Communicate and Report	0010	ORAL COMPREHENSION	26-Receive Digital Message	0.00	1.20	0.00
Communicate and Report	0010	ORAL COMPREHENSION	27-Input data into Computer	0.00	1.20	0.00
Communicate and Report	0010	ORAL COMPREHENSION	28-Send Digital Information	0.00	1.20	0.00

The corresponding MicroSaint™ code after processing by the macro for this example is displayed in Table 9. All of the numbers past the 4th significant digit are the result of roundoff error from Excel that is passed into the data table by the macro and are insignificant in the processing performed by MicroSaint™. Each full table for this manipulation consists of 1600 elements comprising the 50 taxons (ScaleName) times the 5 independent variables (DutyName) times the subset number of DetailDuty elements that pertains to each condition from the task duty set of 32 tasks. In the example above there are 13 detail duties making up the oral comprehension component of communicating and reporting for the battalion commander. See appendix B for full listing of the KSA setup data using treatment condition 1 as an example.

Table 9 – Excerpt of KSA Treatment Data After Excel Macro Processing

WL[1,1,1]:=2.20800004005432;
WL[1,2,1]:=0;
WL[1,3,1]:=2.20800004005432;
WL[1,4,1]:=2.20800004005432;
WL[1,5,1]:=0;
WL[1,6,1]:=0;
WL[1,7,1]:=0;
WL[1,8,1]:=2.20800004005432;
WL[1,9,1]:=0;
WL[1,10,1]:=2.20800004005432;
WL[1,26,1]:=0;
WL[1,27,1]:=0;
WL[1,28,1]:=0;

The second manipulation for dependent variables Taskload from Task Time (TLTT), Utilization (UTIL), Number of Queues Generated During The Run (NOQUE), Number of Times A Task Was Interrupted (TSKINT), Number of Times A Task Was Suspended (TSKSUP), and Number of Times A Task Was Dropped (TSKDRP) was performed by adjusting the task performance time parameters up and down according to the experimental design using the same +/- 20% values as before. An excerpt from the spreadsheet that was used in this step is shown in Table 10. The Number column is the task identification number used by the model. The Name column contains a text name corresponding to the task number. The Operator1 column reflects the primary operator performing this task. The data here indicates operator 29, the battalion commander. The task time data for all of the other operators was left unchanged as only the battalion commander's task time performance data was being adjusted up and down in the experimental design. The Operator2 column contains a placeholder for a secondary operator for the performance of this task. For all of the battalion commander tasks there was no secondary operator. The Function column shows the function category code for the task. The WtFac column indicates a priority weighting factor for the task. The Mean column is the time, in seconds, for the performance of the task. The Interrupt Type column shows the priority level for this task if it tries to interrupt another task. The Original Mean column shows the original mean task time, in seconds, before the experimental design adjustment. The IV Category column shows the independent variable this task feeds into, here showing independent variable #1, Communicate and Report (CAR).

Table 10 – Example of Configuration of Task Time Treatment Levels

802	Receive and Record	29		1	A	0.50	2	0.42	1- CAR	1.2	0.50
825	Receive and Record	29		1	A	0.50	2	0.42	1- CAR	1.2	0.50
817	Pass Info	29		2	A	2.02	2	1.68	1- CAR	1.2	2.02
863	Pass Info	29		2	A	19.66	2	16.38	1- CAR	1.2	19.66
824	Listen Receive	29		3	A	2.02	2	1.68	1- CAR	1.2	2.02

The corresponding MicroSaint™ code after processing by the macro for this example is displayed in Table 11. See Appendix C for a full listing of the Task Time setup data for treatment condition 1.

Table 11 – Example of Task Time Treatment Data After Excel Macro Processing

TaskData[802,OpIndx]:=29;
TaskData[802,DJFIndx]:=1;
TaskData[802,WtIndx]:=A;
TaskData[802,TmIndx]:=0.504;
TaskData[802,IntIndx]:=2;
TaskData[825,OpIndx]:=29;
TaskData[825,DJFIndx]:=1;
TaskData[825,WtIndx]:=A;
TaskData[825,TmIndx]:=0.504;
TaskData[825,IntIndx]:=2;
TaskData[817,OpIndx]:=29;
TaskData[817,DJFIndx]:=2;
TaskData[817,WtIndx]:=A;
TaskData[817,TmIndx]:=2.016;
TaskData[817,IntIndx]:=2;
TaskData[863,OpIndx]:=29;
TaskData[863,DJFIndx]:=2;
TaskData[863,WtIndx]:=A;
TaskData[863,TmIndx]:=19.656;
TaskData[863,IntIndx]:=2;
TaskData[824,OpIndx]:=29;
TaskData[824,DJFIndx]:=3;
TaskData[824,WtIndx]:=A;
TaskData[824,TmIndx]:=2.016;
TaskData[824,IntIndx]:=2;

The Treatment Multiplier column contains a multiplier that is used to adjust the mean task time up or down, here showing a value of 1.2 indicating an adjustment of +20%. The Treatment Product column shows the adjusted task time, in seconds, which is the product of the original mean times the treatment multiplier. This value has also been stored back into the Mean column by the spreadsheet for processing by an Excel macro which translates this information into coded values which were then inserted into the MicroSaint™ model's TASKDATACMD function table.

The 9th treatment combination is termed the zero or center point (CP) value and consists of the original task time and KSA data in the model. As this data was used to generate both the KSA based and Task Time based treatment levels for the independent variables it was applicable to be used for the KSA variable and all of the Task Time dependent variables. There were a total of 18 models configured for this data collection with 9 being for the KSA data treatments and 9

for the Task Time based data treatments. The models were run and data collected and stored for subsequent analysis.

3.3. Apparatus.

The CoHOST simulation model is written in the MicroSaint™ programming language by Micro Analysis and Design Corporation. MicroSaint™ is a discrete event simulation language that is designed to support human performance studies and is applicable for a wide range of human performance domains (Laughery and Corker, 1992). The version used to support this thesis was Release 3.1 Build A with ActionView and OptQuest, Standard Version, that was released on October 27, 1999. The computer system environment supporting the MicroSaint™ simulation is an IBM compatible personal computer using the Microsoft™ Windows 2000 Professional Edition operating system. The hardware specifications of the computer system used is:

- CPU: Pentium II running at 450 MHZ.
- Bus Rate: 133 MHZ.
- Memory: 390 MB.
- Disk storage: 64 GB.

Using this equipment the amount of computer time estimated to run all the treatment combinations is 47.5 hours as shown in Table 12.

Table 12 – Simulation Run Analysis

- 8 Runs Of 15 Replications Repeated 1 Time For Factorial Treatments.	→ 120 Replications.
- 1 Run Of 15 Replications Repeated 10 Times For Center Point.	→ 165 Replications.
- Total Required Replications =	→ 285 Replications.
- Computer Time Required @ 10 Minutes Per Replication :	
> Factorial Treatments:	8 x 15 x 1 x 10 = 1200 minutes = 20.0 Hours
> Center Point Treatment:	1 x 15 x 11 x 10 = 1650 minutes = 27.5 Hours
> Total	= 47.5 Hours

4. Results.

The output data will be analyzed to provide information to generate a set of polynomial regression equations that will describe the performance of the model under its entire range of performance. These equations will be algebraically manipulated to predict the maximum combinations of task times and knowledge, skills, and abilities that will produce the minimum workload for each operator for this work environment within the constraints of the simulation.

The data produced from the simulation runs was evaluated with a series of statistical reviews using the SAS statistical software package (version 8.01 on IBM compatible personal computer running Windows 2000). The resulting regression equations for each dependent variable was then evaluated by taking the partial derivative of each equation and setting it equal to zero to produce a system of simultaneous equations describing the independent variables for each dependent variable. Solving these equations yields the optimum value of the independent variables to minimize the dependent variable.

These analyses begin with tests for multicollinearity in the data followed by development of regression equations for each dependent variable. Each independent variable was tested for significance against each dependent variable using the general linear model procedure. Finally, the regression lack of fit was tested for significance to determine if there were quadratic components existing in the response for the independent variable main effects. A response surface regression analysis was then performed to evaluate these quadratic components.

4.1. Data Collection.

Each model was run for a sufficient number of replications to ensure that 15 valid replications was completed for each treatment condition. Even though this simulation was subjected to a thorough testing sequence during its development it was impossible to test all of the possible task interactions that might be generated when parameters such as task time are changed that would result in different task time performance and differing completion times and follow on sequences of resulting tasks. With 32 different detail level tasks that are coded into the simulation it is theoretically possible that 32 factorial different task interaction combinations can exist in the simulation. As a result, when these data collection runs were conducted there was no way to know in advance if all the task interaction combinations resulting from unique random number seeds and task time adjustments that would result in the run had been previously tested

and would not generate an error. As a result there were, in fact, replications in almost every run that generated errors that MicroSaint™ identified as warnings requiring operator intervention to resume the simulation run and continue on to the next replication. Most of the runs did generate 3 or 4 bad replications and, as a result, each run was set to execute for 20 replications to ensure that 15 good replications were produced. There were a total of 27 simulation runs producing 15 replications each that included 8 runs for the fractional factorial treatments for KSA data, 8 runs for the fractional factorial treatments for the Task Time data, and 11 runs for the center point data. While most runs did produce 3 or 4 bad replications, one run executed error free and one run required almost 50 replications to obtain the required 15 good replications.

Each treatment condition model was configured to produce the full range of output capable from the simulation even though only a small portion of the data from operator 29, the battalion commander, was required for this study. Given the level of effort required to configure and run the models the conclusion was reached to gather and store all possible data on all the 23 operators for possible future research and data mining efforts. As a result of this decision approximately 130 megabytes of data was generated and stored from each simulation run. Two of the 16 output files from each run, UTIL.RES and OPDATA.RES (the MicroSaint™ .RES extension means a results file) contained all of the data required to support this study. This data was first transcribed into a data run spreadsheet. The data run spreadsheet for the KSA treatment 1 simulation run is shown in Table 13. This spreadsheet shows replications 6, 7, 8, and 17 as having failed and replication 20 being not necessary to achieve the required 15 good replications. The 15 data elements were then averaged at the bottom of the spreadsheet to provide the resulting data parameters for that run. The data run spreadsheets for all the 27 simulation runs is at appendix D.

Table 13 – KSA Treatment 1 Data

Random # Seed = 1.0

T1-KSA-PMMMM

Battalion Commander	#	Adj #	Taskload (Workload) (Util)
Replication	1	1	31.99
Replication	2	2	31.88
Replication	3	3	31.95
Replication	4	4	31.88
Replication	5	5	31.68
Replication	6	x	
Replication	7	x	
Replication	8	x	
Replication	9	6	31.92
Replication	10	7	31.99
Replication	11	8	31.92
Replication	12	9	31.96
Replication	13	10	31.77
Replication	14	11	31.81
Replication	15	12	31.84
Replication	16	13	31.80
Replication	17	x	
Replication	18	14	31.88
Replication	19	15	32.00
Replication	20	n	
Average	15		31.88

Following completion of all the simulation runs the data elements from each run wer consolidated into a master spreadsheet that provided the data matrix for the data analysis computer runs. This master spreadsheet is shown in Table 14. As an example the result from the KSA Treatment 1 Data example, 31.88, is reflected in the treatment 1 row for Taskload (KSA). The treatment condition column in this table indicates the treatment levels for the 5 dependent variables according to the experimental design using a shorthand notation where "M" indicates a minus 20% treatment level, "P" indicates a plus 20% treatment level, and "Z" indicates a zero or center point treatment level.

Table 14 – Data Matrix For All Simulation Runs

Battalion Cdr	Run #	Treat - ment Cond.	Treat - ment Range	Ran. # Seed	Taskload [Workload - Task Time] (Util)	Taskload [Workload - KSA] (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Treatment	1	PMMMM	20%	1	39.275		0.9250	49.33	90.33	10.47	9.60
Treatment	2	MPPMM	20%	1	40.084		0.9256	47.13	89.07	10.33	9.40
Treatment	3	PPMPM	20%	1	38.588		0.9213	55.13	88.47	10.47	14.20
Treatment	4	MMPPM	20%	1	36.793		0.9242	51.73	88.47	10.67	12.20
Treatment	5	MPMMP	20%	1	39.810		0.9242	42.80	90.87	10.40	8.93
Treatment	6	PMPMP	20%	1	39.439		0.9244	50.60	90.27	10.80	10.93
Treatment	7	MMMPP	20%	1	39.217		0.9240	48.27	89.07	10.40	11.07
Treatment	8	PPPPP	20%	1	38.891		0.9183	58.47	87.27	9.47	15.33
Treatment	9	ZZZZZ	20%	1	39.439	39.439	0.9244	50.60	90.27	10.80	10.93
Treatment	10	ZZZZZ	20%	2	39.391	39.391	0.9240	49.87	90.47	10.60	11.13
Treatment	11	ZZZZZ	20%	3	39.372	39.372	0.9242	49.87	89.87	10.80	11.13
Treatment	12	ZZZZZ	20%	4	39.351	39.351	0.9243	49.53	90.13	10.93	10.53
Treatment	13	ZZZZZ	20%	5	39.407	39.407	0.9246	50.93	89.60	10.73	10.47
Treatment	14	ZZZZZ	20%	6	39.367	39.367	0.9244	49.67	89.60	10.80	10.93
Treatment	15	ZZZZZ	20%	7	39.320	39.320	0.9246	49.07	90.27	10.73	10.93
Treatment	16	ZZZZZ	20%	8	39.346	39.346	0.9239	49.73	89.87	10.87	10.60
Treatment	17	ZZZZZ	20%	9	40.207	40.207	0.9235	50.00	89.87	10.80	10.87
Treatment	18	ZZZZZ	20%	10	39.340	39.340	0.9238	50.07	89.67	10.73	11.20
Treatment	19	ZZZZZ	20%	11	39.382	39.382	0.9246	50.40	89.80	10.60	10.80

* Data In Shaded Cells From Computer Runs 20-27- Fractional Factorial KSA Runs

In order to be able to interpret the results of the responses of the dependent variables as they relate to each other, the data for each dependent variable was standardized so that it can all be examined along the same period of performance. Using a mean of '0' and a standard deviation of '1' for translation of the data into unit normal form, a new dataset was created. The dependent variable data matrix after standardization is shown in Table 15. This dataset will be used for all of the analytical reviews.

Table 15 – Data Matrix After Standardization

car	drd	eei	usp	mrs	subj	tltt	tlksa	util	noque	tskint	tsksup	tskdrp
1	-1	-1	-1	-1	1	0.01558	-1.61817	0.72212	-0.27519	0.79778	-0.40003	-1.01866
-1	1	1	-1	-1	1	1.17781	-1.45600	1.10148	-0.99729	-0.66798	-0.83082	-1.15316
1	1	-1	1	-1	1	-0.97139	1.52767	-1.61728	1.62852	-1.36595	-0.40003	2.07483
-1	-1	1	1	-1	1	-3.55015	1.68720	0.21630	0.51255	-1.36595	0.21540	0.72984
-1	1	-1	-1	1	1	0.78418	-1.68973	0.21630	-2.41850	1.42595	-0.61543	-1.46923
1	-1	1	-1	1	1	0.25118	-1.38444	0.34276	0.14166	0.72798	0.61543	-0.12424
-1	-1	-1	1	1	1	-0.06775	1.45348	0.08985	-0.62311	-0.66798	-0.61543	-0.03009
1	1	1	1	1	1	-0.53609	1.07270	-3.51409	2.72479	-2.76191	-3.47715	2.83476
0	0	0	0	0	1	0.25118	0.03518	0.34276	0.14166	0.72798	0.61543	-0.12424
0	0	0	0	0	2	0.18223	0.02467	0.08985	-0.09795	0.96064	0.00000	0.01026
0	0	0	0	0	3	0.15493	0.02051	0.21630	-0.09795	0.26266	0.61543	0.01026
0	0	0	0	0	4	0.12476	0.01592	0.27953	-0.20955	0.56512	1.01545	-0.39323
0	0	0	0	0	5	0.20521	0.02817	0.46921	0.24997	-0.05143	0.40003	-0.43358
0	0	0	0	0	6	0.14775	0.01942	0.34276	-0.16359	-0.05143	0.61543	-0.12424
0	0	0	0	0	7	0.08022	0.00913	0.46921	-0.36053	0.72798	0.40003	-0.12424
0	0	0	0	0	8	0.11758	0.01482	0.02662	-0.14390	0.26266	0.83082	-0.34616
0	0	0	0	0	9	1.35452	0.20325	-0.22629	-0.05528	0.26266	0.61543	-0.16459
0	0	0	0	0	10	0.10896	0.01351	-0.03661	-0.03230	0.03000	0.40003	0.05734
0	0	0	0	0	11	0.16930	0.02270	0.46921	0.07601	0.18123	0.00000	-0.21166

4.2. Development of Polynomial Regression Equations.

A set of polynomial regression equations was developed for each dependent variable that will be used to perform a response surface analysis for that variable. The sections below review the requirements for developing these equations and describe the general form that these equations are expected to take.

4.2.1. Data Collection Requirements For Polynomial Regression Equations.

First, there must be one more data point than the number of parameters fitted (Kleinbaum, Kupper, Muller, and Nizam, 1998) (p. 290). This data collection procedure involves five predictors, $X_1 - X_5$, corresponding to the five independent variables of the design. Thus, the number of Beta Weight parameters to be fitted in this equation is equal to the five Beta coefficients for the predictors, $B_1 - B_5$, plus the Beta Weight for the intercept, B_0, which gives six parameters to be fitted. For the ¼ replicate fractional factorial design there are eight treatment conditions generating eight data points which satisfies this criterion.

Second, there must be one more level in the treatment conditions than the highest order of the polynomial (Kleinbaum et al., 1998) (p. 290). The polynomial to be generated here is linear giving a first order polynomial. Therefore, there must be at least two treatment levels for each

predictor. As this is a 2^5 factorial design all the factors have two treatment levels. Therefore, this requirement is satisfied.

Third, there must be some replication of the treatment conditions (i.e., number of subjects per cell) in order to provide a reliable estimation for the error (Kleinbaum et al., 1998) (p. 290). As previously stated there are eleven replications of the center point treatment thereby satisfying this requirement.

4.2.2. Determination of The Regression Equations.

For this 5 factor within subjects design, the general form of the polynomial regression / multiple linear regression equation is shown as Equation 3.

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5$$

Equation 3 – General Form of Expected Polynomial Regression Equation

This equation is repeated for each dependent variable.

4.2.3. Maximizing The Regression Equation Variables.

The first step in determining the maximum value for each variable in the model is to take the partial derivative of each variable:

$$Y'_{X1} = d/(X_1) = B_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5$$
$$Y'_{X2} = d/(X_2) = B_1X_1 + B_2 + B_3X_3 + B_4X_4 + B_5X_5$$
$$Y'_{X3} = d/(X_3) = B_1X_1 + B_2X_2 + B_3 + B_4X_4 + B_5X_5$$
$$Y'_{X4} = d/(X_4) = B_1X_1 + B_2X_2 + B_3X_3 + B_4 + B_5X_5$$
$$Y'_{X5} = d/(X_5) = B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5$$

Set each partial derivative equal to zero to maximize the function:

$$B_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 = 0$$
$$B_1X_1 + B_2 + B_3X_3 + B_4X_4 + B_5X_5 = 0$$
$$B_1X_1 + B_2X_2 + B_3 + B_4X_4 + B_5X_5 = 0$$
$$B_1X_1 + B_2X_2 + B_3X_3 + B_4 + B_5X_5 = 0$$
$$B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5 = 0$$

This now gives 5 equations with 5 unknowns. The procedure is to now solve for the 5 unknowns and substitute the Beta Weights from regression analysis and evaluate the value for each variable

X_1 to X_5. Thus, the equation for each dependent variable will generate a set of optimum values, as predicted by the computer simulation, for the independent variables that will be needed to minimize the dependent variable.

4.2.4. Significance Test Of The Regression Model.

The data from the simulation runs of the augmented ¼ replicate fractional factorial design are included in a multiple regression analysis (Pedhazur, 1997) to construct a first order polynomial function that describes the behavior of the simulation. For the resulting model two descriptors of model validity are computed. The coefficient of correlation, R^2, is a measure of the percentage of the variation in the actual response function that is explained by the regression model. The F ratio is an indication of the statistical significance of the constructed model (Brown and Nachlas, 1985). The F test will select between the two hypotheses:

H_0: Regression model is not statistically different from zero (Null Hypothesis).
H_1: Regression model is significant (Alternate Hypothesis).

Decision Rule: If the calculated value of the F ratio exceeds the corresponding tabulated value for the F distribution, then H_1 is believed true. Otherwise, H_0 is accepted as true.

The regression model ANOVA summary table is shown in Table 16 that was used to generate the F ratios to support the hypothesis tests.

Table 16 – Regression Model Summary Table

	Number of Repititions per Cell (n) =	3
	# of Treatment Combinations That Have Repeated Observations (T) =	9
	Total Data Points (Treatments) (N = n x T) =	27
Source	**df**	**F**
Regression	(5)	
B_1	1	MS_{B1} / MS_{Err}
B_2	1	MS_{B2} / MS_{Err}
B_3	1	MS_{B3} / MS_{Err}
B_4	1	MS_{B4} / MS_{Err}
B_5	1	MS_{B5} / MS_{Err}
Residual	(21)	
Lack Of Fit (LOF)	3	MS_{LOF} / MS_{Err}
Error (Replications) = (n-1) x T =	18	
Total:	(26)	
Verification: N-1 =	26	

4.2.5. Alternative Regression Analysis.

In order to refine the model and reduce the number of required simulation runs, a refinement of the regression model is utilized. This alternative model uses an unbalanced number of treatment combinations where each of the fractional factorial combinations is repeated only once and the center point treatment is repeated multiple times. This design, illustrated in Table 17, termed a 2^{5-2} *plus Center Point With Repeated Observations* design, has the advantages of optimizing the simulation execution with a fewer number of runs as shown in Table 7. The real advantage is that it provides the ability to look for quadratic effects as a result of having the third treatment level that is provided by the center point treatment. The disadvantage of this design is that it is slightly less powerful with only 10 degrees of freedom in the error term versus 18 in the original design.

The analysis procedure to test this model is summarized as follows:

1. Test the linear model for significance of the main effects.
2. Test the LOF for significance.

a. If the LOF is significant then a higher order effect is predicted.

1) Test the 2nd, 3rd, etc. effects for significance.

2) Perform 'Data Snooping' to identify what the higher order polynomial might look like.

However, focus on effects only up to the quadratics of the main effects as human performance is difficult to quantify beyond second order interaction and effects.

Table 17 – Alternative Regression Model Summary Table

	Number of Repititions per Cell (n):	
	1/4 Replicate Treatments = n(1/4) =	8
	1/4 Replicate Treatment Combinations =	1
	* Pick Center Point Treatments = n(cp) =	11
	Number of Data Points That Have Repeated Observations (T) (i.e., the replication of the Center Point) =	1
	Treatment Combinations (N = (n(1/4) + n(cp)) x T) =	19
Source	**df**	**F**
Regression	(5)	
B_1	1	MS_{B1} / MS_{Err}
B_2	1	MS_{B2} / MS_{Err}
B_3	1	MS_{B3} / MS_{Err}
B_4	1	MS_{B4} / MS_{Err}
B_5	1	MS_{B5} / MS_{Err}
Residual	(13)	
Lack Of Fit (LOF)	3	MS_{LOF} / MS_{Err}
Error (Replications) =		
** ((n(cp) -1) x T =	10	
Total:	(18)	
Verification: N-1 =	18	
* Pick n(cp) to cause F Ratio for Beta Weights to be below 5. A value of 11 causes the error term to be equal to 10 with a resulting F ratio = 4.96.		
** Only use data points that have multiple replications, in this case n(cp).		

4.3. Multicollinearity Test.

The terms collinearity, multicollinearity and near collinearity refer to correlations among variables where the two variables are perfectly correlated. This can render the regression statistics on the variables to be useless (Pedhazur, 1997). For this reason the first step in looking at the output data is to check for this condition. A correlation table showing the correlation of

the dependent variables to the independent variables was generated. (The SAS program code and output used to generate this table are at appendix E.) The correlation of the dependent variables against the independent variables from this run is shown in the correlation matrix in Table 18. The top number for each correlation shows R^2 and the bottom number shows the resulting P value. Those correlations that show a significant P value correlation at the .01 level are highlighted with a box drawn around them. The dependent measures TLTT, TLKSA, UTIL, NOQUE, TSKINT and TSKDRP all show a significant correlation to the independent variable USP at the .01 level. These six dependent measures cluster together into a performance group that will be called 'Forming a Mental Model (FMM)'. The performance task FMM is therefore indicated to be the primary attentional focus of the battalion commander and is the conglomerate of activities that should be allocated the most attention when trying to improve the ability to perform the required job functions. NOQUE also shows significance to the CAR IV. The IV's DRD and EEI do not show any correlation significance to any of the dependent measures indicating that the task activities of making decisions and evaluating what the impact of those decisions and actions might be do not significantly occupy the battalion commander's time. To be sure, making decisions and directing that the decisions be carried out is a part of the battalion commander's primary duty in the real world. However, what CoHOST is intimating is that making decisions could well be almost automatic after weighing all the alternatives formed from achieving a complete understanding of the situational picture, and that it occurs without significant mental effort on the part of the battalion commander.

Table 18 – Correlation Matrix For Dependent And Independent Variables

Pearson Correlation Coefficients, N = 19
Prob > |r| under H0: Rho=0

	tltt	tlksa	util	noque	tskint	tsksup	tskdrp
car	0.03460	-0.03310	-0.47420	0.64551	-0.11051	-0.15129	0.47411
	0.8882	0.8930	0.0402	0.0028	0.6524	0.5364	0.0403
drd	0.31714	-0.05695	-0.43205	0.09847	-0.23848	-0.42823	0.22753
	0.1858	0.8169	0.0647	0.6884	0.3255	0.0674	0.3489
eei	-0.20149	0.02052	-0.10538	0.33917	-0.35480	-0.12052	0.22753
	0.4081	0.9336	0.6677	0.1555	0.1361	0.6231	0.3489
usp	-0.61284	0.99078	-0.60066	0.64934	-0.70379	-0.25386	0.78122
	0.0053	<.0001	0.0065	0.0026	0.0008	0.2943	<.0001

4.4. Determination of Polynomial Regression Models.

The goal of this part of the analysis is to determine the optimum polynomial regression models that describes the performance characteristics of each dependent variable. However, since this is a 2^5 experimental design the polynomial regression equations are equivalent to the multiple linear regression case. The multiple linear regression model to be used in this thesis was determined by developing regression parameter estimates (beta weights) for each dependent variable. Using the standardized database, the MRS independent variable for each dependent variable is examined to identify the smallest p value. This value is then used as a threshold to determine which of the other coefficients are significant and whose value should be included in the regression model for that dependent variable. (The SAS program code and run results used to generate these regression coefficients is at appendix F.) The MRS 'p' values is shown in Table 19. The smallest P value is .0209 for the dependent variable UTIL highlighted with an asterisk. This value is therefore used as the threshold for significance to determine which of the independent variables will be used in the regression equation for each dependent variable.

Table 19 – Standardized P Values For The MRS IV For Each DV

		Parameter Estimates			
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
		Dependent Variable: tltt			
mrs	1	0.46996	0.25776	1.82	0.0913
		Dependent Variable: tlksa			
mrs	1	-0.08609	0.04221	-2.04	0.0623
		Dependent Variable: util			
mrs	1	-0.41098	0.15650	-2.63	**0.0209***
		Dependent Variable: noque			
mrs	1	-0.13047	0.07131	-1.83	0.0903
		Dependent Variable: tskint			
mrs	1	0.16577	0.22691	0.73	0.4780
		Dependent Variable: tsksup			
mrs	1	-0.33464	0.33925	-0.99	0.3419
		Dependent Variable: tskdrp			
mrs	1	0.07229	0.10110	0.72	0.4872

The parameter estimates (beta weights) for each dependent measure with a p value greater than .0209 was determined by evaluation of the statistical analysis in Appendix F and is shown in Table 20.

Table 20 – IV Regression Coefficients For The Standardized Data

	IV Title	Comm & Report	Decide & Recommend / Direct	Evaluate & Estimate Impact	Identify / Understand Situational Picture	
DV Title	Variable Code	CAR	DRD	EEI	USP	Intercept
Taskload [Task Time]	TLTT				**-0.919**	**0.000**
Taskload [KSA]	TLKSA				**1.486**	**0.000**
Utilization	UTIL	**-0.711**	**-0.648**		**-0.901**	**0.000**
Number of Queues	NOQUE	**0.968**		**0.509**	**0.974**	**0.000**
Tasks Interrupted	TSKINT				**-1.056**	**0.000**
Tasks Suspended	TSKSUP					**0.000**
Tasks Dropped	TSKDRP	**0.711**	**0.341**	**0.341**	**1.172**	**0.000**

Expressing these coefficients as regression equations generates an expression for the response of each dependent variable to each independent variable. These expressions are shown at Equations 4.

TLTT = -0.919USP
TLKSA = +1.486USP
UTIL = -0.711CAR -0.648DRD -0.901USP
NOQUE = 0.96826CAR + 0.50875EEI +0.974USP
TSKINT = +1.056USP
TSKSUP = 0
TSKDRP = 0.711CAR +0.341DRD +0.341EEI +1.172USP

Equations 4 – Regression Equations From Standardized Data

4.5. Determination of Maximum Values Of Response Surfaces.

In order to determine the maximum value of the response surface for each dependent variable, these equations are set equal to '0', the partial differential taken for each independent variable, and the resulting equation sets solved to provide the values. Using the dependent variable TSKDRP as an example, its regression equation is:

TSKDRP = 0.711CAR +0.341DRD +0.341EEI +1.172USP

Taking the partial derivative of each independent variable gives:

$$
\begin{aligned}
TSKDRP'_{CAR} &= 0.711 + 0.341DRD + 0.341EEI + 1.172USP \\
TSKDRP'_{DRD} &= 0.711CAR + 0.341 + 0.341EEI + 1.172USP \\
TSKDRP'_{EEI} &= 0.711CAR + 0.341DRD + 0.341 + 1.172USP \\
TSKDRP'_{USP} &= 0.711CAR + 0.341DRD + 0.341EEI + 1.172
\end{aligned}
$$

Setting each partial derivative equal to zero gives:

$$
\begin{aligned}
0.711 + 0.341DRD + 0.341EEI + 1.172USP &= 0 \\
0.711CAR + 0.341 + 0.341EEI + 1.172USP &= 0 \\
0.711CAR + 0.341DRD + 0.341 + 1.172USP &= 0 \\
0.711CAR + 0.341DRD + 0.341EEI + 1.172 &= 0
\end{aligned}
$$

Expressing these equations in matrix form as shown in Figure 11 and solving (MathSoft, 2001) for the 4 unknowns gives:

Taskload From Number of Tasks Dropped - TSKDRP

$$
M := \begin{pmatrix} 0 & 0.34129 & 0.34129 & 1.17183 \\ 0.71117 & 0 & 0.34129 & 1.17183 \\ 0.71117 & 0.34129 & 0 & 1.17183 \\ 0.71117 & 0.34129 & 0.34129 & 0 \end{pmatrix} \qquad v := \begin{pmatrix} -0.71117 \\ -0.34129 \\ -0.34129 \\ -1.17183 \end{pmatrix}
$$

$$
soln := lsolve(M, v)
$$

$$
soln = \begin{pmatrix} -0.203 \\ -1.506 \\ -1.506 \\ 0.27 \end{pmatrix}
$$

Figure 11 – Determination of Maximum Regression Values

Expressing the results back into equation form gives the maximum value in the response surface for each independent measure for the dependent measure TSKDRP:

$$
\begin{aligned}
CAR &= -0.203 \\
DRD &= -1.506 \\
EEI &= -1.506 \\
USP &= 0.27
\end{aligned}
$$

The solutions for all the dependent variables is at appendix G. Table 21 shows the maximum response surface value for each of the dependent measures.

Table 21 – Response Surface Maximum Values For Standardized Data

Standardized Data	IV Title	Comm & Report	Decide & Recommend / Direct	Evaluate & Estimate Impact	Identify / Understand Situational Picture
DV Title	Variable Code	CAR	DRD	EEI	USP
Taskload [Task Time]	TLTT				-0.919
Taskload [KSA]	TLKSA				1.486
Utilization	UTIL	-0.589	-0.744		-0.254
Number of Queues	NOQUE	-0.503		-0.957	-0.022
Tasks Interrupted	TSKINT				1.056
Tasks Suspended	TSKSUP				
Tasks Dropped	TSKDRP	-0.203	-1.506	-1.506	0.270

This data is shown graphically in Figure 12.

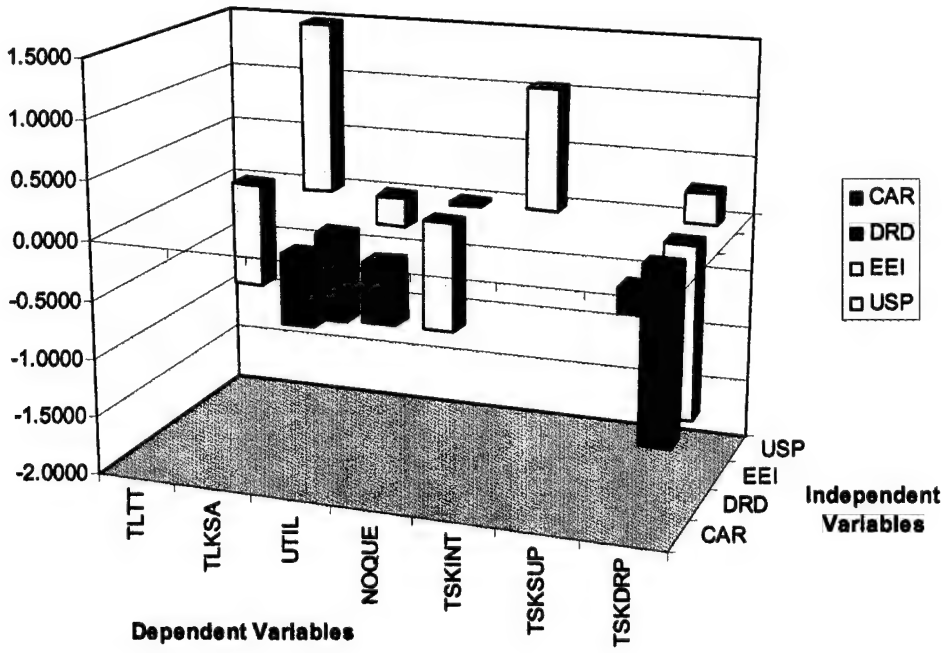

Figure 12 – Response Surface Maximum Values For Each IV To Each DV

4.6. Significance Test Of Each DV To Each IV.

From the Regression Model ANOVA summary table design presented in Table 17, the results of statistical tests performed to establish the significance of each dependent variable to each independent variable is presented in Regression ANOVA tables in Appendix I. The determination of significance for LOF is determined by a manual evaluation using a decision rule and comparing a tabled F ratio to the observed F ratio as calculated. These LOF calculations are also at Appendix I and is summarized in Table 22. An example of a Regression ANOVA table is shown for the dependent variable TLTT in Table 23.

Table 22 – Summary of LOF Tests of Significance

LOF Significance Tests		
F Ratio	Value	Significant ?
$F_{tabled\text{-}LOF} = F_{(3,10)} =$	6.550	
$F_{observed\text{-}LOF\text{-}TLTT} =$	13.952	Yes
$F_{observed\text{-}LOF\text{-}TLKSA} =$	16.644	Yes
$F_{observed\text{-}LOF\text{-}UTIL} =$	12.872	Yes
$F_{observed\text{-}LOF\text{-}NOQUE} =$	2.761	No
$F_{observed\text{-}LOF\text{-}TSKINT} =$	11.782	Yes
$F_{observed\text{-}LOF\text{-}TSKSUP} =$	38.297	Yes
$F_{observed\text{-}LOF\text{-}TSKDRP} =$	9.551	Yes

Table 23 – Regression ANOVA Summary Table For Dependent Variable TLTT

Regression ANOVA Summary Table				
Augmented 1-4 Replicate 2-5 Design				
	Alternative Regression ANOVA			
Number of center point treatments, n(cp) =		11		
Number of Data Points That Have Repeated Observations				
(T) (i.e., the replication of the Center Point) =		1		
Treatment Combinations, N (n(1/4) + n(cp) x T) =		19		
Source	**df**	**MS**	**F**	**P**
Regression	(5)			
CAR	1	0.010	0.160	0.696
DRD	1	0.877	13.590	0.004
EEI	1	0.354	5.480	0.041
USP	1	3.276	50.730	<.0001
MRS	1	0.856	13.260	0.005
Residuals	(13)			
Lack Of Fit (LOF)	3	0.901	13.952	*Significant
Error ((n(cp) -1) x T)	10	0.065		
Total:	(18)			
Verification: N-1 =	18			

* From manual decision rule test.

4.7. Identification of Higher Order Components For Main Effects.

Following the identification of LOF significance comes the task of identifying what the higher order response looks like for those variables found to have a significant LOF. One caveat, however, is that in human factors work it is rarely possible to interpret interactions and responses higher than the second order. Thus, the effort here will focus on identifying only the quadratic responses and in attempting to determine what their response surface looks like.

After determining which dependent variables are predicted to have a quadratic response to at least one of the independent variables, the second step is to identify which second order effects are significant. Because this experimental design only has 3 treatment levels resulting from the augmented ¼ replicate fractional factorial design, there is not enough data to resolve the quadratic components of the main effects. An alternate manual approach is therefore taken where a 2 dimensional response plot of each dependent variable against each independent

variable is generated in EXCEL. Subjective interpretation of these plots then establishes the response order for each of the dependent measures. Each dependent variable that has been shown to be contributing to the response surface in at least a quadratic form as shown by the LOF test results in Table 23 needs to be examined to see which of the independent variables it is generating a quadratic response to. Because of the nature of the experimental design these results cannot be obtained directly from response surface regression runs. This is due to the fact that the design being used can be considered an incomplete central composite design (CCD) where the fractional factorial data points are collocated with what would otherwise be the face centered data points in a true CCD. Thus, attempts to generate the quadratic results for the 3 levels in the design multiply the +1 and +1 treatments and the –1 and –1 treatments and arrives at +1 for both conditions thereby reducing the number of treatments for the quadratic analysis from 3 to 2. As one more treatment level than the order of the analysis is required to perform the test, anything higher than a linear analysis is not possible. A true CCD would have 5 treatment levels with the α values being away from the face centered levels of the fractional factorial data points and would allow at least a quadratic resolution of the results.

This information can still be obtained, however, from manually interpreting a graph of the response for each dependent variable for each dependent variable. The data for each treatment level for each dependent variable is averaged to provide a response value for that dependent variable against each independent variable. This provides three data points for each condition that can be plotted to display the response characteristic of that treatment for the IV/DV combination. Using EXCEL these plots were generated using the curve smoothing option to produce the response line for the dependent measure. These plots are then examined to see which dependent measure is demonstrating a quadratic response. The data matrix of the data generated by averaging the treatment data is in Table 24 and a sample of these plots is shown in Figure 13. A complete printing of all the plots is in appendix J.

Table 24 – Average of Treatment Data For Each IV/DV Combination

		tltt/CAR	tlksa/CAR	util/CAR	noque/CAR	tskint/CAR	tsksup/CAR	tskdrp/CAR
Average of Sum of -1 data	-1	-1.65591	-0.00504	1.62394	-3.52635	-1.27595	-1.84628	-1.92264
Average of Sum of 0 data	0	0.26333	0.03703	0.22205	-0.06304	0.35255	0.50073	-0.16764
Average of Sum of 1 data	1	-1.24072	-0.40224	-4.06650	4.21977	-2.60211	-3.66178	9.57071
		tltt/DRD	tlksa/DRD	util/DRD	noque/DRD	tskint/DRD	tsksup/DRD	tskdrp/DRD
Average of Sum of -1 data	-1	-3.35114	0.13808	1.37103	-0.24410	-0.50818	-0.18463	5.36087
Average of Sum of 0 data	0	0.26333	0.03703	0.22205	-0.06304	0.35255	0.50073	-0.16764
Average of Sum of 1 data	1	0.45451	-0.54536	-3.81359	0.93751	-3.36988	-5.32343	2.28720
		tltt/EEI	tlksa/EEI	util/EEI	noque/EEI	tskint/EEI	tsksup/EEI	tskdrp/EEI
Average of Sum of -1 data	-1	-0.23939	-0.32674	-0.58901	-1.68829	0.18980	-2.03090	5.36087
Average of Sum of 0 data	0	0.26333	0.03703	0.22205	-0.06304	0.35255	0.50073	-0.16764
Average of Sum of 1 data	1	-2.65725	-0.08054	-1.85355	2.38171	-4.06786	-3.47715	2.28720
		tltt/USP	tlksa/USP	util/USP	noque/USP	tskint/USP	tsksup/USP	tskdrp/USP
Average of Sum of -1 data	-1	2.22875	-6.14834	2.38266	-3.54932	2.28373	-1.23085	2.03873
Average of Sum of 0 data	0	0.26333	0.03703	0.22205	-0.06304	0.35255	0.50073	-0.16764
Average of Sum of 1 data	1	-5.12538	5.74106	-4.82522	4.24274	-6.16179	-4.27720	5.60934

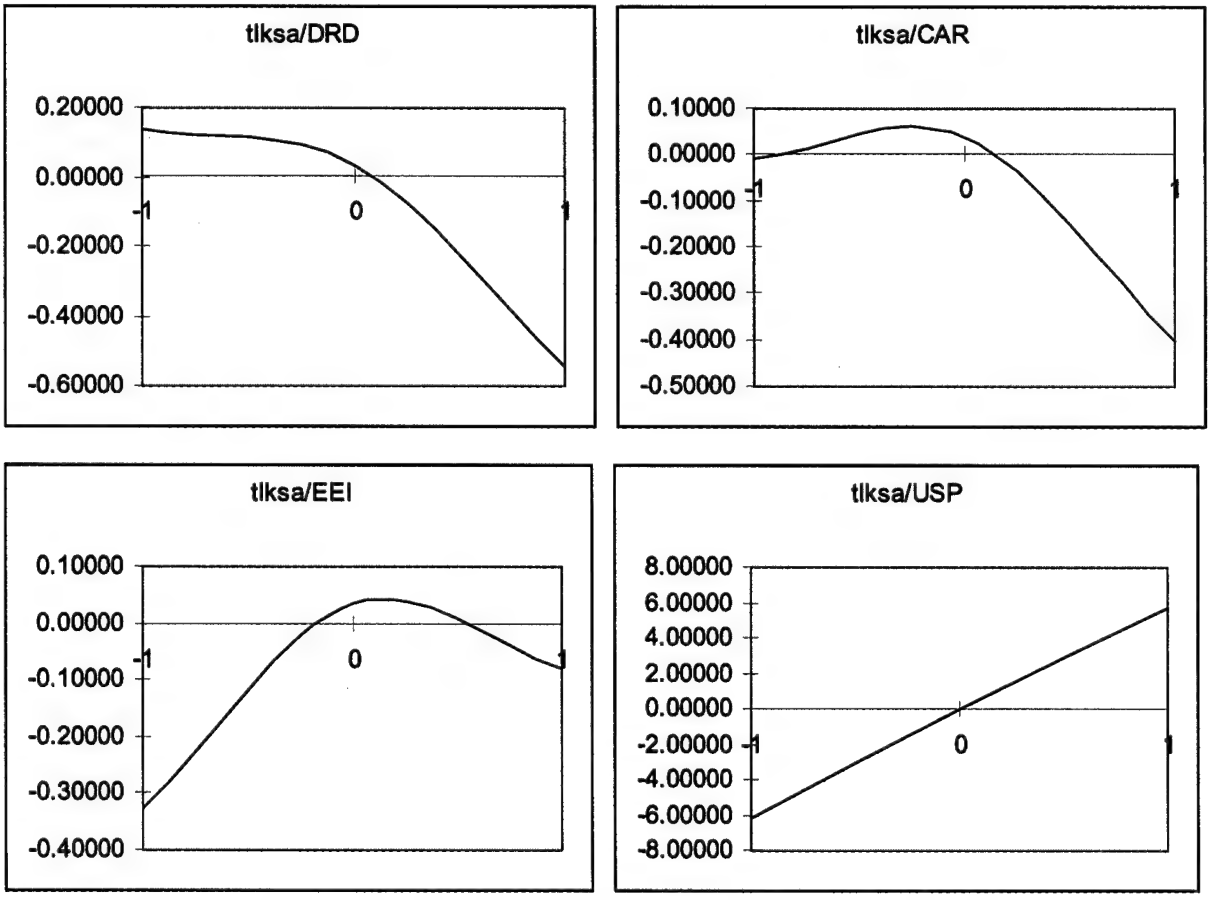

Figure 13 – Independent Variable Response Plots For Dependent Variable TLKSA

Table 25 expands the previous LOF significance test table to show the order of the probable response surface effects from the subjective evaluation of the plots.

Table 25 – Summary of Interpretation of Response Order For The DV's

LOF Significance Tests			Interpretations of Response Surface Plots			
F Ratio	Value	Significant ?	Order of Response			
$F_{tabled\text{-}LOF} = F_{(3,10)} =$	6.550		CAR	DRD	EEI	USP
$F_{observed\text{-}LOF\text{-}TLTT} =$	13.952	Yes	2	2	2	1-2
$F_{observed\text{-}LOF\text{-}TLKSA} =$	16.644	Yes	1-2	1-2	2	1
$F_{observed\text{-}LOF\text{-}UTIL} =$	12.872	Yes	1	1	2	1
$F_{observed\text{-}LOF\text{-}NOQUE} =$	2.761	No	1	1	1	1
$F_{observed\text{-}LOF\text{-}TSKINT} =$	11.782	Yes	2	2	1-2	1-2
$F_{observed\text{-}LOF\text{-}TSKSUP} =$	38.297	Yes	2	2	2	2
$F_{observed\text{-}LOF\text{-}TSKDRP} =$	9.551	Yes	1-2	2	2	2

Legend:

2 - Indicates probable quadratic response.
1 - Indicates probable linear response.
1-2 - Curve could be either linear or quadratic.

All of the interpretations of these response curves involve subjective opinion as to the nature of the curve. Those that are coded as quadratic indicate enough variability to be probably interpreted as quadratic. However, only one of the curves coded as linear showed clearly a straight line response. This curve was for the TLKSA vs. USP response. All of the rest of the curves interpreted as linear showed a minimum amount of curve in the line which was attritibuted to random variability in the model and were interpreted as probably linear. All of the curves coded as '1-2' are probably linear, however, subjective assessment can not state with complete confidence that there is no quadratic component in the response.

5. Discussion.

The development of methodologies to capitalize on the use of computer simulations to support empirical research begins with a step by step look first at statistical procedures that are applicable to the type of experimental designs that might be used. Noting that numerical results alone are often hard to understand by clients for whom the research is being conducted, the second phase in the methodology is to interpret the results in terms of the work situation that the simulation is describing. The approach here is to invoke accepted human performance models from teamwork and macroergonomic literature to provide a framework for translating the results of the research into terminology that these individuals can accept and utilize. This thesis uses the CoHOST simulation as a platform to illustrate the development of these methodologies. In the process of this effort conclusions and recommendations are produced from CoHOST that are of interest to the original Army CoHOST clients.

This section begins with descriptions of the statistics involved in the study that include correlations, development of regression equations, and attempts to determine the existence of higher order effects in the dependent variables. A team performance model is then used to provide a basis for the explanation of the statistical results. The major focus, however, of the discussion are descriptions of the methodology as a whole and how the CoHOST model was used both to develop the methods and then provide an example of their use. Implications of the work are discussed along with discussions of where the research can go from here and suggestions for future work.

5.1. Predictions From Correlation Table.

The interpretation of Table 18 provides insights into what this simulation model is predicting for the activities of the battalion commander. These results indicate that the battalion commander is not spending any significant amount of time or devotion of mental and physical resources to either the activities of Deciding and Recommending or Directing (DRD) or Evaluating and Estimating Impact (EEI). Referring to the nature of activities in a battalion tactical operations center (TOC) and the fact that the battalion commander spends the majority of the available time displaced forward of the TOC roaming the front line in a command and control vehicle, it is consistent with observed real world activities that these types of duties would be relegated to subordinates, particularly the executive officer and the battle captain. The

dependent variable 'Number of Times a Task Was Suspended (TSKSUP) did not correlate with any of the independent variables thereby suggesting that interrupted tasks were more likely to be eventually dropped rather than being held in a suspended status for eventual interruption. As this computer model simulates activities under actual combat conditions where the time and stress pressures are high, this is a consistent conclusion where the battalion commander is predominately focused on those activities requiring immediate attention and is referring less time sensitive issues to subordinates.

There are two dependent measures that evaluate the effects of task load on this operator. The 'Taskload from Task Time (TLTT)' measure looks at the amount of taskload imposed on the battalion commander as a result of how long it takes to perform individual tasks. The 'Taskload from KSA (TLKSA)' measure looks at the taskload imposed as a result of the amount of knowledge, skills, and abilities, primarily cognitive and psychomotor, that the battalion commander must allocate to the task in order to satisfy it. Both of these measures significantly correlate only to the independent measure 'Understand Situational Picture (USP)'. The dependent measure 'Number of Times a Task Was Interrupted (TSKINT) also only significantly correlates to USP. When these activities are then combined with the dependent measure Utilization (UTIL), a picture begins to emerge of what the correlation statistics are predicting to be the primary focus of the battalion commander's activities.

This focus is a predominate amount of attention and activities to developing and maintaining a clear understanding of the evolving battlefield situation and then when necessary communicating that knowledge along with directives and orders back to the TOC and the company commanders being directed. These activities consume the battalion commander's focus and attention to the point that the operator is constantly being interrupted by changes in the situation he or she is trying to maintain an awareness of and possibly by communication and coordination queries from subordinates as well as from contemporaries and superiors.

The other dependent measures that significantly correlate to the independent variables are 'Number of Queues Generated During the Run (NOQUE)' and 'Number of Tasks That Were Dropped During the Run (TSKDRP)'. This is consistent with the above assessment that there are many task based demands that are placed on the battalion commander that have to wait their turn for attention and the fact that many of them time out and are considered to be dropped as they never get processed. The simulation tracks the timing of each task and considers that if a

task is not perform within a specified period of time then the information and requirements of that task have become obsolete and the task is therefore dropped.

5.2. Regression Equation Results.

Plots of the response surface maximum values in Figure 12, supported by the table of regression coefficients in Table 20, contribute to an evolving picture of what is generating the highest demands on the battalion commander. The regression coefficients closely resemble the correlation results that show a strong dominance of activities directed toward performance of the understand situational picture (USP) independent variable. Also coinciding between the two results is the strong response of the dependent variable TSKDRP (number of tasks dropped) that significantly responds to all the independent variables. Thus, the comments of the preceding section are echoed with the regression solutions that show the battalion commander predominately focused on tasks associated with understanding the evolving battlefield situation as it is perceived through the observation and communication means that is available. The primary secondary focus is communication based activities to issue and receive directives. As new, immediate priority issues attract the battalion commander's attention, it is most likely that the tasks being currently performed will be interrupted to attend to the new high priority issue which means that the tasks currently being performed, once interrupted, are likely to become obsolete by virtue of timing out and will therefore get dropped and never completed.

5.3. Estimates Of Higher Order Effects.

As previously described, the assessment of quadratic effects in the responses of the dependent variables to the main effects has been a highly subjective process in this study. Because of the nature of the experimental design that was optimized for data gathering efficiency there is simply not enough data to support direct calculation of the quadratic effects using statistical procedures with tools such as SAS. It was not realized until late in the analysis process that these limitations would become a concern, however, it points out the adage that 'nothing comes for free'. If extended time had been available to gather a full ½ or even full ¼ replicate fractional factorial number of treatments or a full CCD worth of treatments there would have been enough data points to support quadratic assessments of the main effects.

However, without the necessary data for actual qualitative results the study is relegated to a subjective examination of the results that are obtainable from the data. The plots showing the

responses of the dependent variables to each independent variable along the 3 data points resulting from the 3 treatment combinations at least provides clues as to what is occurring in the model. Referring to these plots in appendix J and the interpretation of their meaning in Table 26, predictions can be made as to the probability of higher order actions occurring in the simulation. The general criteria used in the interpretation of the plots was that if the curves crossed the x axis twice the interaction probably contains some quadratic effect. Because of the previous attention to the TSKDRP dependent variable and the USP independent variable the relationship between them is considered first. By the criteria above this response shows a probable quadratic effect. In performance terms this indicates that the battalion commander is regarding the battlefield situational assessments with greater and lesser amounts of attention and time according to the number and severity of the events being observed. The results of this activity would be a changing number of existing tasks not being completed, or becoming dropped, as attentional focus is constantly being changed while trying to maintain an accurate mental model of the battlefield. Conversely, the model output seems to show that the remainder of the activity response is probably linear in nature with a straight line proportional response to the demands of the other task types.

5.4. Mapping A Macroergonomic Model To The CoHOST Predictions.

After the predicted human performance and environmental domain characteristics have been determined from the above analysis, it is important to lay aside the simulation and the experimental design manipulations and ask the question, "what does it mean?" in the context of real world performance issues. This query may be addressed according to a structured approach such as can be found from a number of macroergonomic framework models. A teamwork model that is particularly suited for this purpose is shown in Figure 14 that "examines team building and its influence on team effectiveness" (Swezey and Llaneras, 1997; Tannenbaum, Beard, and Salas, 1992). This model, called the team effectiveness model (TEM), integrates the aspects of several models that were developed to explain team processes and outcomes (Weaver, Bowers, Salas, and Cannon-Bowers, 1995). Adapting Tannenbaum's definition of what a team is into the military command and control domain defines a team as two or more people who are interacting toward a common mission. Similar definitions abound in the literature (Weaver et al., 1995). The 23 individuals from the 1000 member battalion task force who are engaged in command and control operations in the battalion tactical operations center (TOC) clearly meet this definition of

a functioning team. The battalion commander is, without question, the leader of this team although this person typically is not collocated with most of the team members during combat operations. Attempts to improve the functioning of a team, often called team building, generally focus on improving team operations by doing such things as removing barriers to effective operations and clarifying roles of the individual team members.

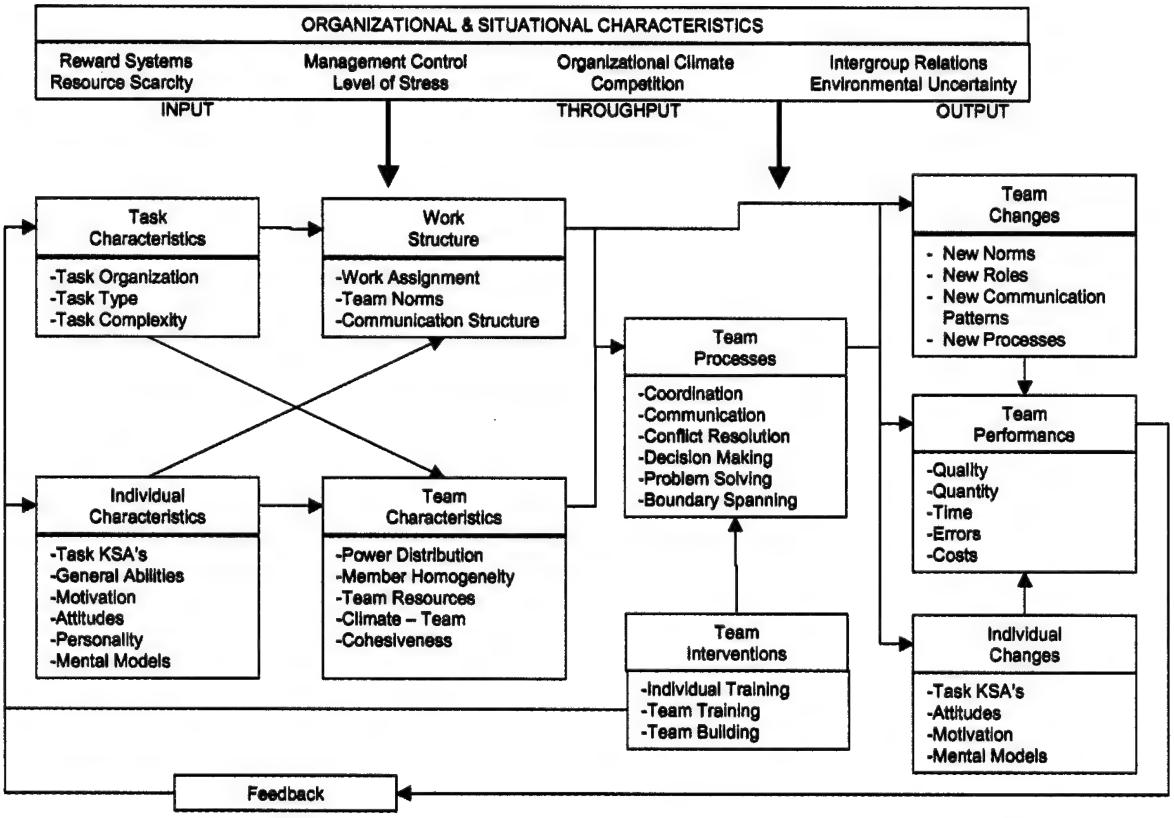

Figure 14 – Team Effectiveness Model
(Tannenbaum et al., 1992)

The basic nature of the TEM model follows the general systems theory paradigm of input-throughput-output much the same as the basic structure of the CoHOST model itself. Among other things, this model describes team inputs as the characteristics of the tasks presented to the team. This coincides with the input structure to the CoHOST model with task performance generating communication messages arriving to the workgroup from higher, lower, and adjacent organizational elements. Throughputs in the Tannenbaum model are described as

the manner in which the team performs its interactions over time. These are words which can identically be used to describe the throughput functioning of the CoHOST simulation. Finally, the outputs from the TEM model are primarily the quality and quantity of the products produced by the team. In the CoHOST model this translates to the decisions made by the team, primarily the battalion commander, and the communication of these decisions to other organizational elements outside the team. There are some characteristics of the Tannenbaum model that are not reflected in CoHOST. For example, Tannenbaum considers that there are other outputs in the team functioning beyond just the primary output of team performance. Such things as changes in the team makeup or organization resulting in new roles and interactions and a greater or lesser cohesiveness to be team outputs as well. The CoHOST model limits itself to strictly looking at the resulting performance of the team as the measure of team output.

One advantage of using a simulation model such as CoHOST over live subjects with empirical observation is that exact repeatability can be obtained that transcends the normal fluctuations that can occur in team performance due to human interpersonal differences in skill levels, opinion, dedication, and attention to detail, for example. While individual characteristics of different operators performing the same job can be approximated with different sequences of random variability, the simulated operators can be held as a constant while varying the demands of the work domain. CoHOST provides this performance medium, within the constraints of its simulated battlefield scenario and the taxonomically described capabilities of each operator, where the demands and task performance abilities of one operator, such as the battalion commander, can be looked at in isolation but yet within the performance constraints of the overall team. To be certain, there are limitations in a simulation based approach to evaluate individual and team decision making and performance. It is noted (Cannon-Bowers, Salas, and Pruitt, 1996) that it is not possible to apply empirically based decision making analyses to many real world situations because these approaches do not account for the decision maker's experience nor the complexity of the task or the true demands of the environment. Also, there must be a full understanding of what the simulation is and is not addressing and there is a continuing need for researchers to 'systematically test the components of the model in order to determine their relative importance' (Weaver et al., 1995).

Analyses performed in previous sections have established some measure of the primary attention focus of the battalion commander. It must be reemphasized that these conclusions and

the results of this experimental observation are from the world according to CoHOST. One of the primary assumptions made before the study began was that there was a computer simulation model available that accurately (i.e., is believable to a specified performance interval and that the risk of error involved in using it is within acceptable limits) postulated a particular human performance domain. The name of the model is CoHOST and the performance domain is the command and control work group in a U.S. Army battalion level tactical operations center conducting combat operations. Whatever the level of risk assessed to be associated with the use of the model also accompanies the reliability of the results generated by it. Before this thesis study began a formal risk assessment according to the Failure Modes and Effects Analysis (FMEA) procedure (Croxall and Wood, 1989; Goddard and Davis, 1984; Knepell and Arangno, 1993) established that the risk associated with the use of this simulation was within acceptable limits for the, then, current study.

Assuming that the results from CoHOST can be believed, therefore, then the focus on improving the ability of the battalion commander to perform all the required duties for the job would be to improve the tools available to maintain an assessment of the surrounding situation along with longer range and improved communications systems to enable this individual to always be in communication with all the members of the team.

5.5. Major Findings.

The significance of the results of this research is primarily in the area of the development of new methods for the use of pre-existing computer simulations of human performance to allow optimized evaluations of their predictive performance abilities. Regardless of the original predictive algorithmic functions that might exist in the simulation and the questions that originally drove the development of these algorithms, the use of experimental design and regression techniques can allow these functions to assume a new role in predictions of how to optimize those functions to maximize human performance. A series of guidelines, derived from these methods, are illustrated in the specific case of the work domain described by the CoHOST simulation to comment on how to improve the performance of command and control teams in an Army TOC.

The guidelines presented here fall into three categories. These categories are experimental design, simulation, and analysis. See Table 26 for a summary of the guidelines and sections 5.5.1 and 5.5.2 for complete descriptions.

Table 26 – Guidelines For Simulation Based Experimentation

Type	#	Description
Experimental Design	1	Determine level of design.
Experimental Design	2	Determine lowest number of treatments required for desired resolution.
Experimental Design	3	Determine of the design needs to be augmented.
Experimental Design	4	Use manual calculations as required to extend the analysis.
Experimental Design	5	Consider the use of unbalanced treatments to reduce required number of simulation runs.
Simulation	1	Establish an acceptable level of risk for use of the simulation.
Simulation	2	Determine the number of required replications of the simulation.
Simulation	3	Use dummy IV to have simulation self report its significance levels.
Analysis	1	Determine whether the data should be standardized.
Analysis	2	Interpret analysis results in terms of real world constructs.

5.5.1. Methodology for Human Performance Analysis Using Experimentally Interrogated Simulations.

The first step in experimentally interrogating a simulation is to develop an appropriate experimental design. This generally is an iterative process that starts first with a basic design that is then modified according to operational constraints and requirements. This methodology can be dynamic in that the modifications conform to the specifications of the simulation used, however, many of the steps and considerations can be generalized to the point that they are not unique to a specific simulation. With the example simulation as provided by CoHOST, after identifying the number of independent measures and treatment levels, a basic 2^5 experimental design emerged. The first step or guideline is to ask the question,

- Experimental Design Guideline (1). Can the design be conducted as a full factorial experiment? If the answer is "yes" then conduct it. If the answer is "no" then precede to guideline 2.

For CoHOST this means 32 treatment combinations resulting from the 2^5 design. First, there was not enough time to make all the simulation runs to support these treatments, and second, a full factorial experiment would be very inefficient as it would collect data to support higher level interactions that could not be interpreted. For situations such as this the next guideline is invoked:

- Experimental Design Guideline (2). Reduce the design fractionally until the lowest number of treatments that will satisfy the resolution requirement is provided.

For CoHOST this involved evaluating ½ replicate and ¼ replicate fractional factorial designs. A ½ replicate design of 16 treatments would provide for a Resolution V design that resolves all the main effects and two way interactions. Since only the main effects are of interest and the two way interactions cannot be interpreted for CoHOST, this resolution is still too inefficient and subject to further reduction. A ¼ replicate design of 8 treatments provides for Resolution III that will resolve all the main effects and some of the two-way interactions. Proceeding on to a 1/8 design would not resolve the main effects and so a ¼ replicate fractional factorial design is considered the optimum level for CoHOST. The next guideline looks at the level of analysis capable from the design:

- Experimental Design Guideline (3). Can higher order effects from the main effects and / or interactions be examined with this design? If "yes" then proceed with the design, if "no" then investigate whether the design can be augmented with additional treatments.

For the ¼ replicate 2^5 fractional factorial design in CoHOST this answer is "no". While only two treatment levels provides for efficient execution of the simulation, it limits the resulting analysis to only an evaluation of the linear components of the main effects and does not support a response surface or dependent variable response analysis of higher order components for these variables. The CoHOST data was then examined for possible additional treatment combinations. As the existing two treatments were generated from plus and minus deltas from the original data in the model, this existing data could be considered as a center point treatment as is normally the case in a central composite design. Using this treatment now provided a third treatment level for the design with the valued added capability to theoretically evaluate higher order components of the output data. The cost of adding this third treatment level to a 2^5 design is that it is no longer a true 2^5 design. Also, unless the treatments are recalculated for a 3 level design it remains a 2 level design that is augmented that provides some capability for examining higher order effects but does not generate enough data points to support a full calculated quadratic evaluation of the output. In order to keep the number of simulation runs within a manageable level with CoHOST the decision was made to stay with the 2 level design and use manual workaround methods to evaluate the higher order effects as closely as possible. This leads to the next guideline which addresses how to address data that supports analysis higher than the original design but does not generate enough data for a full higher level analysis.

- Experimental Design Guideline (4). If full analysis of the output data is not possible to the desired level, use manual calculations and procedures from the existing data to make predictions of what the higher order interactions might be.

For CoHOST the desire was to investigate whether or not there were quadratic components of the main effects. The third center point treatment level provided this ability, but as the design remained basically a two treatment level design with not enough data collected to support a full three level design a direct statistical calculation of the quadratic effects was not possible. The manual workarounds involved the calculation of the response surface maximum values for each DV/IV combination and plotting the DV response curves for each 3 value dataset. Subjective interpretation of these curves supported by LOF calculations that predicted the presence of higher order effects was then used to make the predictions as to the possibility of the presence of the higher order effects.

If the number of required simulation runs to support all the treatments in the design must be reduced further to achieve the ability to run the experiment then unbalanced treatments can be considered according to the next guideline:

- Experimental Design Guideline (5). To minimize the required number of computer runs, unbalance the treatments by reducing the fractional factorial treatments to one and repeat the center point treatment as many times as necessary to achieve an acceptable error level.

This was performed with CoHOST and the center point treatment was repeated 11 times. This resulted in a total of (8 fractional factorial + 11 center point =) 19 computer runs which is significantly less than the required 27 runs if each treatment had been repeated 3 times simulating 3 subjects per treatment. It is speculated that the negative aspect of this unbalancing of treatments with only one repetition of the fractional factorial treatments is that random variability in the model was higher than would have been the case with higher number of repetitions of each treatment. Additional computer runs would be required for a full 3 repetition (or more) per treatment case of complete balancing to verify this speculation.

5.5.2. Model Requirements for Analysis Using Experimentally Interrogated Simulations.

The literature is replete with descriptions of requirements for conducting studies using simulation (Banks, 1998; Banks et al., 1996; Knepell and Arangno, 1993; Laughery and Corker, 1992; Law, 1997; Law and Kelton, 1991; Law and Kelton, 2000; Pew and Mavor, 1997;

Zachary, Ryder, Hicinbothom, and Bracken, 1997), however, based on the observations gathered here, a few points should be emphasized. First, and foremost, the simulation must be trusted.

> ➢ Simulation Guideline (1). The simulation must have been evaluated to the point that an acceptable level of risk is established whereby the users are willing to risk using the simulation vice live testing thereby enabling the simulation to be considered a 'black box' that describes a system to an acceptable level of resolution and used to answer questions about that operational system.

The original development of the CoHOST simulation included an extensive verification and validation process followed by a formal failure modes analysis to identify its weaknesses. This was followed by a risk assessment performed by the model developers that satisfied the users of the simulation at that time. Although the project ended before the simulation received full accreditation, it satisfied all of the user requirements then placed upon it for use.

After the determination of the type and extent of the experimental design to be placed upon it, the simulation needs to be evaluated for random variability.

> ➢ Simulation Guideline (2). The number of replications to be executed per simulation treatment run needs to be determined to account for random variability in the model.

CoHOST was evaluated according to a method in the literature (Banks et al., 1996) and was found to require 15 replications to satisfy this requirement. This simulation is typical of most simulations in that it invokes multiple dependent measures and requires that each of them be evaluated by the process. The dependent variable that results in the most required replications then becomes the defining variable for this requirement. After all the replications are executed for a simulation run the data from all the replications is averaged to produce the data for the treatment condition of the simulation run.

While the above guidelines merely restate accepted practices in a form applicable to this type of study, the next guideline is not known to exist in the literature and overcomes a problem common in regression equation analyses. While attempting to fit regression equations to the data and determine which elements are significant and which should be eliminated, the researcher is commonly left to his or her own devices to rationalize a level of significance to be used to accept or reject a particular data parameter. To overcome this subjective requirement computer simulations can be queried to reveal what the level of significance for random variability in the simulation is for the given set of input characteristics.

- Simulation Guideline (3). Use a dummy independent variable in the experimental design for the simulation and then make computer runs that supposedly test this variable. From the resulting statistical analysis use the p value for this value as the cutoff threshold to determine significance for the other variables.

This process allows for the exact determination of unmanipulated variability in the simulation which can be used in place of the traditional table lookup values of .05, .01, or .001 and regression techniques such as forward, backward, and stepwise selection of regression equation terms. This technique was used in the CoHOST model and was compared with the results from the standard forward, backward, and stepwise regression selections using a statistical analysis package. The resulting equations caused more terms in the regression equation to be dropped thereby indicating a closer fit of the final equations.

Although not explicitly a simulation method, considerations must be given to the nature of the data produced by it and how that data is to be evaluated in the analysis phase. Because of the ability of computer simulations to generate large quantities of data very quickly, this consideration can take on added importance to preclude having a large quantity of data after the simulation runs that might be overly difficult or impossible to resolve in the manner desired. Although computer simulation can be fast, this speed is often used to generate more output data than would be normally possible and the time may not exist to rerun the computers if the data is not in a usable form. In human factors research one of the considerations for the output data is whether the dependent measures will be evaluated individually or as a group. If each dependent variable is to be evaluated independently then the output data might be used as produced. If the dependent measures are to be considered as a group then other procedures may be performed first.

- Analysis Guideline (1). If multiple dependent measures are to be analyzed as a group for significance effects, the data should be standardized before the analysis is conducted.

The dependent measures in the CoHOST simulation could not be directly compared to each other because of the values involved. For example, percent utilization was on a 100% scale, taskload was a dimensionless quantity, and the task based measures were all counts. By standardizing these measures to a mean of "0" and a standard deviation of "1" the data all became normalized along a common scale and they could all be compared together.

Analytical procedures and statistical methods can provide a good description of what the data is predicting, however, the descriptions of such results many times can only be understood by those conversant in statistical and research procedures. It is to the system developers, who originally posed the questions that research and simulations try to answer, that the results need to be tailored. Individual, team, and macroergonomic performance descriptions and models can be used to satisfy this need.

- Analysis Guideline (2). The final data and study conclusions should be interpreted / translated into real world constructs and meaningful descriptions pertinent to the original system domain that generated the research.

This study pursued this goal by taking the results from the CoHOST interrogation and relating it to a human performance model from the team performance and macroergonomic literature. Further descriptions and examples using a scenario based approach have attempted to illustrate how the realizations of the conclusions from the study can have meaning in the originating work domain.

5.5.3. A Simulation Example – U.S. Army Battalion Command And Control Team.

The procedures were developed in this thesis according to the structure and requirements of the CoHOST model. While they are therefore constrained by the capabilities, limitations, and organization of CoHOST, they nevertheless, embody constructs and concepts that can apply to a wide range of scenarios and simulations. The requirement to evaluate real world scenarios that may not yet exist, may be too costly to operate, may be too dangerous to the operator for full scale testing or may just take too long to evaluate can be readily addressed in the rapidly evolving world of computer simulation. Many research procedures that are applicable to conventional empirical research are equally applicable in the computer simulation, however, the unique capabilities that simulation based research brings to the researcher can often be enhanced by procedures that are unique to simulation based research or that are not even a consideration in conventional research.

Use of the simulation requires answers to questions related to acceptance of risk, how much is good enough in the replication provided by the simulation and a very important role for subject matter experts to define what the simulation needs to replicate and then judge if the replication is good enough.

The CoHOST computer simulation addresses work domain issues that the Army is still trying to resolve today. While it is a very Army specific investigation into human computer interface (HCI) issues, the basic nature of the work domain and the procedures, concepts and constructs used in the simulation are not limited to just the Army or military applications. Any work team that functions in a decision oriented, high stress, time oriented work situation could be addressed by this type of simulation which could provide insights as to what work activities, priorities, and coordination activities are most important to the successful functioning of the team.

To apply a CoHOST simulation in another work domain that could capitalize on the methodologies contained in this thesis would require primarily database type descriptions of that work domain. The job tasks would have to be identified and applied to the human performance taxonomy. SME's from the new domain would need to identify which taxons apply to each task performed by individuals in the work domain and the level of the application. Work and information flow activities would need to be diagrammed and charted and individual task based activities associated with each construct in the work flow charts. From these data the MicroSaint™ computer code would be revised to reflect the new activities in the new domain.

For the case of the CoHOST model, the specifics that this model and set of research guidelines and methodologies establish are all areas for which there is no known correct answer as it applies to work domain situations that are in near constant development along almost iterative development lines. While this model was programmed to investigate command and control at the battalion level because that is what the original clients for the effort were interested in, the activities and interactions of this 23 member work team are very similar to span of control interactions for commanders at ever higher levels of the chain of command. The battalion commander commands a 1000 member battalion, the brigade commander a 5,000 member brigade, the division commander a 15,000 member division and so on, the critical members working directly with the commander at any level constitute a similar work team at each of the levels. The main difference is that team members at higher levels have access to more resources as the level goes up, but the basic activities they perform are very similar. The questions that CoHOST addresses as to what the communication requirements are, who needs to make what decision, and who needs to take what action for each situational requirement are all able to be investigated to determine if decision making, battlefield assessment, development of accurate

mental models, sharing of those models, evaluating the impact of decisions or inter / intra team communications are the most important and required activity at any one time. Once these requirements and their priorities are quantified then steps can begin to tailor the work situation to give priority to those activities.

5.6. Topics For Future Research.

This thesis has set the stage for continuing research in several areas. The work covered in this study is only the beginning of what is envisioned as an ongoing effort in simulation based experimental research with a focus in team performance especially in the area of military command and control. While the CoHOST simulation has been used as a tool to develop and refine methodological procedures for the use and analysis of simulation based research, the topical area of this simulation provides a rich medium for investigative analysis and development of procedures, priorities, and mental schema as it applies to team based command and control. The age old quandary of what came first, 'the chicken or the egg', applies to this situation where simulations like CoHOST and others like it provide the medium for the investigative analysis, but logically defined methodologies and procedures for the use of the model and the conduct of the resulting analysis provide the ability to interpret and understand what is and is not being predicted.

5.6.1. Implications For The Methodology.

The implication for the research methods described here, some of which were revealed during the pursuit of other priorities, is that continued refinement and optimization of both the data gathering and analysis process should be pursued. This effort needs to be extended into several areas. First, the compromise between the desire for as few a number of simulation runs as possible and the desire for the ability to fully explore the output data statistically needs to be better resolved. While it may not always be feasible to predict how much resolution should exist in the data until the process of analyzing and data mining begins, careful and well thought out experimental designs can allow the establishment of the level of analysis that is capable before the data is collected. Each time the simulation is run in response to a predictive question the modifications to the procedures and requirements to tailor the methodology and simulation to the circumstance of the test can add to the knowledge base of the methodology. In addition, the analysis in this thesis only involved multiple looks at univariate data. The multiple dependent

measures produced by CoHOST and almost any other comparable model are ripe for multivariate examination and could start to provide the ability to answer what some of the effects from second order interactions might be.

Second, future research can focus on the concept of extending or improving the way the simulation model self-reports its limits. The use of dummy variables in the experimental design needs to be more thoroughly investigated. The issue of unmanipulated variability and 'random number noise' should be examined with the intent of reducing it as much as possible while still allowing explicit random variation to simulate the effects of individual human variability in performance. Tests with different random variates and random distributions can establish which profile best meets the criteria. This could also be compared to similar studies using live human test subjects (if they exist and / or can be conducted) to try and fit simulated random variability as close as possible to actual human variability.

5.6.2. Implications For The CoHOST Example.

The use of CoHOST in this thesis involved its use in an unmodified state except for the performance data as it is stored inside the MicroSaint™ computer simulation file. This was important to illustrate how preexisting simulations can be utilized for applications beyond their original intent. However, the CoHOST example represents a defining nature of the research requirements for future work. Questions about the Army command and control domain and how to improve it continue to be a focus of Army force and system developers. Therefore, future use of computer simulation to investigate human performance requirements in the military command and control domain need to focus on models like CoHOST as an exploratory tool to look at the demands that these evolving work domains might or do place on human operators. To be sure, CoHOST is not unique in this application area. One simulation (Essens, Post, and Rasker, 2000) takes a similar but separate approach where the computational entities in the model are organized around "information entities and the functions that generate or transform them" while CoHOST focuses on information entities and their processing through the team organizations. Therefore, while the current CoHOST model is not currently in continued development, there are refinements to be made that can improve its ability to simulate the domain. Indeed, any simulation of the real world is a continued candidate for improvement as it will always only be an approximation of the actual world state and the more that development is invested in it the

tighter the approximation will become. The possible improvement areas for CoHOST or a CoHOST derivative or next generation simulation fall into two primary areas. These are data structure improvements and model algorithmic improvements.

Data structure improvement needs in CoHOST include, first, a revalidation of the taxonomy used to quantify the performance levels of individual tasks. While Fleishman's taxonomy provides a general descriptive base for this kind of application, it is not widely accepted in the work performance community and other descriptive formats such as Wickens' dual task methodology (Wickens and Hollands, 2000) or some of the cognitive and multiple task analysis procedures covered by work of researchers like Klein and Damos (Damos, 1991; Klein, 2000) might provide a more current framework. Second, the SME opinion based data needs to be totally revised and updated. It is envisioned that simulation based human performance research needs to be extensively supported by expert opinion on how and which parts of the performance taxonomy apply to individual task elements. The more SME's that can be involved the more refined the data becomes. This querying of SME opinion should be conducted in parallel with naturalistic observation of human performance for each of the operators in the simulation for each of the task based conditions in the simulation. Where live empirical research typically gathers performance data from a few subjects under strictly controlled conditions over a short period of time, simulated empirical research of human performance should pursue these same efforts only after naturalistic observations of live human performance in real world situations validates the structure and format of individual task performance constructs so that they can be combined and observed in controlled environments that can be exactly repeated under varying conditions in the simulation.

Future research for simulations like CoHOST itself are envisioned as a next generation effort to expand the simulation from just a network based task performance emulator and tracker that is an apt description of the basic functionality in CoHOST, to a whole series of interlinked performance modules that evaluate incoming information as to parameters such as its type, priority, impact, and potential impact that then produce information processing results. The previously referred to naval command center model (Essens et al., 2000) describes some of the components that this kind of model would include:

- Organization model.
- Agent model.

- Knowledge model.
- Event handling model.
- Coordination model.
- Means model.
- Information model.
- Function information model.

A fully implemented simulation of this type would include complete performance databases for each of the functional areas. Each functional model would be an independent program perhaps running on separate computers for processor efficiency and would be supported by its own naturalistically derived and developed performance data for that functional sub-area.

5.7. Conclusions.

The next step for this research is clear and encompasses both the methodology (i.e., process) and the results (or product). Continued refinement of the experimental design is needed to support a more extensive analysis capability while still keeping the computing requirements to a minimum.

The product of this research is the predictive results that can be obtained from models like CoHOST using the methodologies developed to support and drive it. For this case, referring to the original project that developed the CoHOST models, it is noted that one of the previous conclusions was that increased efficiency of communications systems as they were being designed actually degraded the cognitive performance of the decision makers. Of course, the primary decision maker for this work group is the battalion commander. The results from this thesis correspond with these observations with the conclusion that the battalion commander's primary attentional focus is based on developing and maintaining a mental model that allows a continuing understanding of the situational picture associated with the spread of activities in the battlefield being observed while trying to direct. Both of these observations, arrived at from totally different approaches to the use of the CoHOST model, very directly point to changes in the work environment for the battalion commander that could be made to optimize the required cognitive capabilities. The original study illustrated that changes should be made to increase the amount of time available for the proactive think ahead reasoning type of task performance. This thesis focuses this further by illustrating that the tasks of monitoring and understanding the situational picture is the most important. Effective performance in these activities allow the

battalion commander the ability to operate more effectively in a leadership role in the team and directly places this individual within activities as described by models such as the TEM. Therefore, automated aids developed for this operator should not focus on just providing more information arriving at quicker rates that requires more attention to decipher and understand. Rather, the work environment should be optimized to provide displays that show battlefield intelligence information that is fused to indicate its meaning. For example, an automated display should not show information such as 'three BTR 60 armored vehicles are moving into the sector'. Instead it should reflect the information that scout elements preceding an enemy mechanized infantry division are approaching and this indicates that there is one hour before being faced with a massive attack with a probable force ratio of 9 to 1 against the friendly positions. Now, instead of spending time trying to figure out what the meaning, if any, of the presence of these 3 vehicles is, the battalion commander can spend the precious hour available by directing and coordinating a response to the impending attack.

The research methods described by this thesis consist primarily of refinements of conventional approaches that would and do apply in general to empirical research. The tailoring of the techniques for implementation within a simulation based investigative environment along with procedures for operation of the simulation itself is considered the primary contribution of this thesis to the knowledge base. However, it is the application of these techniques using an appropriate tool such as CoHOST that enables answers and predictive evaluations to be made about current system worlds that are too difficult to investigate by conventional means or for future system worlds that do not yet exist.

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Appendices

Appendix A – Determination of ¼ Replicate Fractional Factorial Treatment Combinations.

1. List all possible treatment combinations for a 2^5 full factorial design:

Treatment	A	B	C	D	E
1	0	0	0	0	0
2	1	0	0	0	0
3	0	1	0	0	0
4	1	1	0	0	0
5	0	0	1	0	0
6	1	0	1	0	0
7	0	1	1	0	0
8	1	1	1	0	0
9	0	0	0	1	0
10	1	0	0	1	0
11	0	1	0	1	0
12	1	1	0	1	0
13	0	0	1	1	0
14	1	0	1	1	0
15	0	1	1	1	0
16	1	1	1	1	0
17	0	0	0	0	1
18	1	0	0	0	1
19	0	1	0	0	1
20	1	1	0	0	1
21	0	0	1	0	1
22	1	0	1	0	1
23	0	1	1	0	1
24	1	1	1	0	1
25	0	0	0	1	1
26	1	0	0	1	1
27	0	1	0	1	1
28	1	1	0	1	1
29	0	0	1	1	1
30	1	0	1	1	1
31	0	1	1	1	1
32	1	1	1	1	1

S

2. Divide into 2 blocks according to the C1 identity relationship:

First Identity Relationship: C1: X1 + X2 + X4 = 0 (Mod. 2) = ABD

Treatment	[redacted]	C	[redacted]	E	ABD (Mod. 2)	
1		0		0	0	1
4		0		0	0	2
5		1		0	0	3
8		1		0	0	4
10		0		0	0	5
11		0		0	0	6
14		1		0	0	7
15		1		0	0	8
17		0		1	0	9
20		0		1	0	10
21		1		1	0	11
24		1		1	0	12
26		0		1	0	13
27		0		1	0	14
30		1		1	0	15
31		1		1	0	16
2		0		0	1	17
3		0		0	1	18
6		1		0	1	19
7		1		0	1	20
9		0		0	1	21
12		0		0	1	22
13		1		0	1	23
16		1		0	1	24
18		0		1	1	25
19		0		1	1	26
22		1		1	1	27
23		1		1	1	28
25		0		1	1	29
28		0		1	1	30
29		1		1	1	31
32		1		1	1	32

Steps:

1. Evaluate Factors A,B,D for Mod. 2.
2. Sort on the Mod. 2 evaluation to identify the 2 blocks for this identity relationship.

C1: X1 + X2 + X4 = 0 (Mod. 2) = ABD

3. Sub-divide into 4 blocks according to the C2 identity relationship:

Second Identity Relationship: C2: X1 + X3 + X4 = 0 (Mod. 2) = ACE

Steps:
1. Evaluate Factors A,C,E for Mod. 2.
2. Sort on the Mod. 2 evaluation to identify the 2 blocks for this identity relationship.

Treatment	B	D	ACE (Mod. 2)	#
1	0	0	0	1
8	1	0	0	2
11	1	1	0	3
14	0	1	0	4
20	1	0	0	5
21	0	0	0	6
26	0	1	0	7
31	1	1	0	8
4	1	0	1	9
5	0	0	1	10
10	0	1	1	11
15	1	1	1	12
17	0	0	1	13
24	1	0	1	14
27	1	1	1	15
30	0	1	1	16
3	1	0	0	17
6	0	0	0	18
9	0	1	0	19
16	1	1	0	20
18	0	0	0	21
23	1	0	0	22
28	1	1	0	23
29	0	1	0	24
2	0	0	1	25
7	1	0	1	26
12	1	1	1	27
13	0	1	1	28
19	1	0	1	29
22	0	0	1	30
25	0	1	1	31
32	1	1	1	32

C2: X1 + X3 + X4 = 0 (Mod. 2) = ACE

C1: X1 + X2 + X4 = 0 (Mod. 2) = ABD

C2: X1 + X3 + X4 = 0 (Mod. 2) = ACE

4. Select the 4th block for the ¼ Replicate treatment combinations:

Second Identity Relationship: C2: X1 + X3 + X4 = 0 (Mod. 2) = ACE

Treatment	A	B	C	D	E	ABD (Mod. 2)	ACE (Mod. 2)	#
1	0	0	0	0	0	0	0	1
8	1	1	1	0	0	0	0	2
11	0	1	0	1	0	0	0	3
14	1	0	1	1	0	0	0	4
20	1	1	0	0	1	0	0	5
21	0	0	1	0	1	0	0	6
26	1	0	0	1	1	0	0	7
31	0	1	1	1	1	0	0	8
4	1	1	0	0	0	0	1	9
5	0	0	1	0	0	0	1	10
10	1	0	0	1	0	0	1	11
15	0	1	1	1	0	0	1	12
17	0	0	0	0	1	0	1	13
24	1	1	1	0	1	0	1	14
27	0	1	0	1	1	0	1	15
30	1	0	1	1	1	0	1	16
3	0	1	0	0	0	1	0	17
6	1	0	1	0	0	1	0	18
9	0	0	0	1	0	1	0	19
16	1	1	1	1	0	1	0	20
18	1	0	0	0	1	1	0	21
23	0	1	1	0	1	1	0	22
28	1	1	0	1	1	1	0	23
29	0	0	1	1	1	1	0	24
2	[redacted]					1	1	25
7						1	1	26
12						1	1	27
13						1	1	28
19						1	1	29
22						1	1	30
25						1	1	31
32						1	1	32

C2: X1 + X3 + X4 = 0 (Mod. 2) = ACE

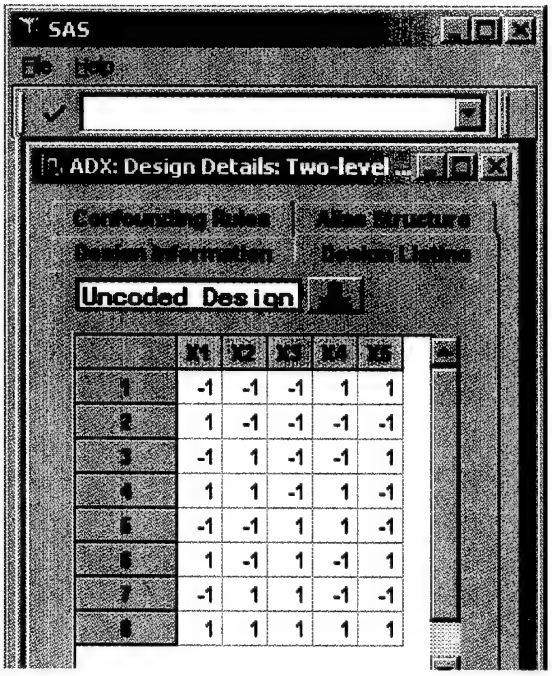
C1: X1 + X2 + X4 = 0 (Mod. 2) = ABD

C2: X1 + X3 + X4 = 0 (Mod. 2) = ACE

5. Convert to +/- notation:

1	-1	-1	-1	-1
-1	1	1	-1	-1
1	1	-1	1	-1
-1	-1	1	1	-1
-1	1	-1	-1	1
1	-1	1	-1	1
-1	-1	-1	1	1
1	1	1	1	1

Comparing this selection to the SAS ADX Experimental Design module, this agrees with the treatment block selected by SAS as:



	X1	X2	X3	X4	X5
1	-1	-1	-1	1	1
2	1	-1	-1	-1	-1
3	-1	1	-1	-1	1
4	1	1	-1	1	-1
5	-1	-1	1	1	-1
6	1	-1	1	-1	1
7	-1	1	1	-1	-1
8	1	1	1	1	1

Appendix B – KSA Treatment Condition 1 Setup Table.

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
2	Communicate and Report	0010	ORAL COMPREHENSION	01-Receive and Record/Analog	1.84		1.20	2.21
3	Communicate and Report	0010	ORAL COMPREHENSION	02-Pass Information	0.00		1.20	0.00
4	Communicate and Report	0010	ORAL COMPREHENSION	03-Listen-Receive Information	1.84		1.20	2.21
5	Communicate and Report	0010	ORAL COMPREHENSION	04-Secondary Monitor	1.84		1.20	2.21
6	Communicate and Report	0010	ORAL COMPREHENSION	05-Log Message	0.00		1.20	0.00
7	Communicate and Report	0010	ORAL COMPREHENSION	06-Route (Outside the Section)	0.00		1.20	0.00
8	Communicate and Report	0010	ORAL COMPREHENSION	07-Send Message	0.00		1.20	0.00
9	Communicate and Report	0010	ORAL COMPREHENSION	08-Verbal Order	1.84		1.20	2.21
10	Communicate and Report	0010	ORAL COMPREHENSION	09-Roll Up Reports	0.00		1.20	0.00
11	Communicate and Report	0010	ORAL COMPREHENSION	10-Call to Conference	1.84		1.20	2.21
12	Communicate and Report	0010	ORAL COMPREHENSION	26-Receive Digital Message	0.00		1.20	0.00
13	Communicate and Report	0010	ORAL COMPREHENSION	27-Input data Into Computer	0.00		1.20	0.00
14	Communicate and Report	0010	ORAL COMPREHENSION	28-Send Digital Information	0.00		1.20	0.00
15	Communicate and Report	0020	WRITTEN COMPREHENSI(	01-Receive and Record/Analog	1.54		1.20	1.85
16	Communicate and Report	0020	WRITTEN COMPREHENSI(	02-Pass Information	0.00		1.20	0.00
17	Communicate and Report	0020	WRITTEN COMPREHENSI(	03-Listen-Receive Information	1.54		1.20	1.85
18	Communicate and Report	0020	WRITTEN COMPREHENSI(	04-Secondary Monitor	1.54		1.20	1.85
19	Communicate and Report	0020	WRITTEN COMPREHENSI(	05-Log Message	1.54		1.20	1.85
20	Communicate and Report	0020	WRITTEN COMPREHENSI(	06-Route (Outside the Section)	0.00		1.20	0.00
21	Communicate and Report	0020	WRITTEN COMPREHENSI(	07-Send Message	0.00		1.20	0.00
22	Communicate and Report	0020	WRITTEN COMPREHENSI(	08-Verbal Order	0.00		1.20	0.00
23	Communicate and Report	0020	WRITTEN COMPREHENSI(	09-Roll Up Reports	1.54		1.20	1.85
24	Communicate and Report	0020	WRITTEN COMPREHENSI(	10-Call to Conference	0.00		1.20	0.00
25	Communicate and Report	0020	WRITTEN COMPREHENSI(	26-Receive Digital Message	1.54		1.20	1.85
26	Communicate and Report	0020	WRITTEN COMPREHENSI(	27-Input data Into Computer	1.54		1.20	1.85
27	Communicate and Report	0020	WRITTEN COMPREHENSI(	28-Send Digital Information	1.54		1.20	1.85
28	Communicate and Report	0030	ORAL EXPRESSION	01-Receive and Record/Analog	2.30		1.20	2.76
29	Communicate and Report	0030	ORAL EXPRESSION	02-Pass Information	2.30		1.20	2.76
30	Communicate and Report	0030	ORAL EXPRESSION	03-Listen-Receive Information	0.00		1.20	0.00
31	Communicate and Report	0030	ORAL EXPRESSION	04-Secondary Monitor	0.00		1.20	0.00
32	Communicate and Report	0030	ORAL EXPRESSION	05-Log Message	0.00		1.20	0.00
33	Communicate and Report	0030	ORAL EXPRESSION	06-Route (Outside the Section)	0.00		1.20	0.00
34	Communicate and Report	0030	ORAL EXPRESSION	07-Send Message	2.30		1.20	2.76
35	Communicate and Report	0030	ORAL EXPRESSION	08-Verbal Order	2.30		1.20	2.76
36	Communicate and Report	0030	ORAL EXPRESSION	09-Roll Up Reports	0.00		1.20	0.00
37	Communicate and Report	0030	ORAL EXPRESSION	10-Call to Conference	2.30		1.20	2.76
38	Communicate and Report	0030	ORAL EXPRESSION	26-Receive Digital Message	0.00		1.20	0.00
39	Communicate and Report	0030	ORAL EXPRESSION	27-Input data Into Computer	0.00		1.20	0.00
40	Communicate and Report	0030	ORAL EXPRESSION	28-Send Digital Information	0.00		1.20	0.00
41	Communicate and Report	0040	WRITTEN EXPRESSION	01-Receive and Record/Analog	1.26		1.20	1.51
42	Communicate and Report	0040	WRITTEN EXPRESSION	02-Pass Information	0.00		1.20	0.00
43	Communicate and Report	0040	WRITTEN EXPRESSION	03-Listen-Receive Information	0.00		1.20	0.00
44	Communicate and Report	0040	WRITTEN EXPRESSION	04-Secondary Monitor	1.26		1.20	1.51
45	Communicate and Report	0040	WRITTEN EXPRESSION	05-Log Message	1.26		1.20	1.51
46	Communicate and Report	0040	WRITTEN EXPRESSION	06-Route (Outside the Section)	0.00		1.20	0.00
47	Communicate and Report	0040	WRITTEN EXPRESSION	07-Send Message	0.00		1.20	0.00
48	Communicate and Report	0040	WRITTEN EXPRESSION	08-Verbal Order	0.00		1.20	0.00
49	Communicate and Report	0040	WRITTEN EXPRESSION	09-Roll Up Reports	1.26		1.20	1.51
50	Communicate and Report	0040	WRITTEN EXPRESSION	10-Call to Conference	0.00		1.20	0.00
51	Communicate and Report	0040	WRITTEN EXPRESSION	26-Receive Digital Message	0.00		1.20	0.00
52	Communicate and Report	0040	WRITTEN EXPRESSION	27-Input data Into Computer	1.26		1.20	1.51
53	Communicate and Report	0040	WRITTEN EXPRESSION	28-Send Digital Information	1.26		1.20	1.51
54	Communicate and Report	0050	MEMORIZATION	01-Receive and Record/Analog	0.00		1.20	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
55	Communicate and Report	0050	MEMORIZATION	02-Pass Information	0.00		1.20	0.00
56	Communicate and Report	0050	MEMORIZATION	03-Listen-Receive Information	0.00		1.20	0.00
57	Communicate and Report	0050	MEMORIZATION	04-Secondary Monitor	0.00		1.20	0.00
58	Communicate and Report	0050	MEMORIZATION	05-Log Message	0.00		1.20	0.00
59	Communicate and Report	0050	MEMORIZATION	06-Route (Outside the Section)	0.00		1.20	0.00
60	Communicate and Report	0050	MEMORIZATION	07-Send Message	0.00		1.20	0.00
61	Communicate and Report	0050	MEMORIZATION	08-Verbal Order	0.00		1.20	0.00
62	Communicate and Report	0050	MEMORIZATION	09-Roll Up Reports	0.00		1.20	0.00
63	Communicate and Report	0050	MEMORIZATION	10-Call to Conference	0.00		1.20	0.00
64	Communicate and Report	0050	MEMORIZATION	26-Receive Digital Message	0.00		1.20	0.00
65	Communicate and Report	0050	MEMORIZATION	27-Input data Into Computer	2.26		1.20	2.71
66	Communicate and Report	0050	MEMORIZATION	28-Send Digital Information	2.26		1.20	2.71
67	Communicate and Report	0060	PROBLEM SENSITIVITY	01-Receive and Record/Analog	0.00		1.20	0.00
68	Communicate and Report	0060	PROBLEM SENSITIVITY	02-Pass Information	2.01		1.20	2.41
69	Communicate and Report	0060	PROBLEM SENSITIVITY	03-Listen-Receive Information	0.00		1.20	0.00
70	Communicate and Report	0060	PROBLEM SENSITIVITY	04-Secondary Monitor	0.00		1.20	0.00
71	Communicate and Report	0060	PROBLEM SENSITIVITY	05-Log Message	0.00		1.20	0.00
72	Communicate and Report	0060	PROBLEM SENSITIVITY	06-Route (Outside the Section)	0.00		1.20	0.00
73	Communicate and Report	0060	PROBLEM SENSITIVITY	07-Send Message	0.00		1.20	0.00
74	Communicate and Report	0060	PROBLEM SENSITIVITY	08-Verbal Order	0.00		1.20	0.00
75	Communicate and Report	0060	PROBLEM SENSITIVITY	09-Roll Up Reports	0.00		1.20	0.00
76	Communicate and Report	0060	PROBLEM SENSITIVITY	10-Call to Conference	0.00		1.20	0.00
77	Communicate and Report	0060	PROBLEM SENSITIVITY	26-Receive Digital Message	0.00		1.20	0.00
78	Communicate and Report	0060	PROBLEM SENSITIVITY	27-Input data Into Computer	0.00		1.20	0.00
79	Communicate and Report	0060	PROBLEM SENSITIVITY	28-Send Digital Information	0.00		1.20	0.00
80	Communicate and Report	0070	ORIGINALITY	01-Receive and Record/Analog	0.00		1.20	0.00
81	Communicate and Report	0070	ORIGINALITY	02-Pass Information	0.00		1.20	0.00
82	Communicate and Report	0070	ORIGINALITY	03-Listen-Receive Information	0.00		1.20	0.00
83	Communicate and Report	0070	ORIGINALITY	04-Secondary Monitor	0.00		1.20	0.00
84	Communicate and Report	0070	ORIGINALITY	05-Log Message	0.00		1.20	0.00
85	Communicate and Report	0070	ORIGINALITY	06-Route (Outside the Section)	0.00		1.20	0.00
86	Communicate and Report	0070	ORIGINALITY	07-Send Message	0.00		1.20	0.00
87	Communicate and Report	0070	ORIGINALITY	08-Verbal Order	0.00		1.20	0.00
88	Communicate and Report	0070	ORIGINALITY	09-Roll Up Reports	0.00		1.20	0.00
89	Communicate and Report	0070	ORIGINALITY	10-Call to Conference	0.00		1.20	0.00
90	Communicate and Report	0070	ORIGINALITY	26-Receive Digital Message	0.00		1.20	0.00
91	Communicate and Report	0070	ORIGINALITY	27-Input data Into Computer	0.00		1.20	0.00
92	Communicate and Report	0070	ORIGINALITY	28-Send Digital Information	0.00		1.20	0.00
93	Communicate and Report	0080	FLUENCY OF IDEAS	01-Receive and Record/Analog	0.00		1.20	0.00
94	Communicate and Report	0080	FLUENCY OF IDEAS	02-Pass Information	0.00		1.20	0.00
95	Communicate and Report	0080	FLUENCY OF IDEAS	03-Listen-Receive Information	0.00		1.20	0.00
96	Communicate and Report	0080	FLUENCY OF IDEAS	04-Secondary Monitor	0.00		1.20	0.00
97	Communicate and Report	0080	FLUENCY OF IDEAS	05-Log Message	0.00		1.20	0.00
98	Communicate and Report	0080	FLUENCY OF IDEAS	06-Route (Outside the Section)	0.00		1.20	0.00
99	Communicate and Report	0080	FLUENCY OF IDEAS	07-Send Message	0.00		1.20	0.00
100	Communicate and Report	0080	FLUENCY OF IDEAS	08-Verbal Order	0.00		1.20	0.00
101	Communicate and Report	0080	FLUENCY OF IDEAS	09-Roll Up Reports	0.00		1.20	0.00
102	Communicate and Report	0080	FLUENCY OF IDEAS	10-Call to Conference	0.00		1.20	0.00
103	Communicate and Report	0080	FLUENCY OF IDEAS	26-Receive Digital Message	0.00		1.20	0.00
104	Communicate and Report	0080	FLUENCY OF IDEAS	27-Input data Into Computer	0.00		1.20	0.00
105	Communicate and Report	0080	FLUENCY OF IDEAS	28-Send Digital Information	0.00		1.20	0.00
106	Communicate and Report	0090	FLEXIBILITY OF CLOSURE	01-Receive and Record/Analog	0.00		1.20	0.00
107	Communicate and Report	0090	FLEXIBILITY OF CLOSURE	02-Pass Information	0.00		1.20	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
108	Communicate and Report	0090	FLEXIBILITY OF CLOSURE	03-Listen-Receive Information	1.42		1.20	1.70
109	Communicate and Report	0090	FLEXIBILITY OF CLOSURE	04-Secondary Monitor	0.00		1.20	0.00
110	Communicate and Report	0090	FLEXIBILITY OF CLOSURE	05-Log Message	0.00		1.20	0.00
111	Communicate and Report	0090	FLEXIBILITY OF CLOSURE	06-Route (Outside the Section)	0.00		1.20	0.00
112	Communicate and Report	0090	FLEXIBILITY OF CLOSURE	07-Send Message	0.00		1.20	0.00
113	Communicate and Report	0090	FLEXIBILITY OF CLOSURE	08-Verbal Order	0.00		1.20	0.00
114	Communicate and Report	0090	FLEXIBILITY OF CLOSURE	09-Roll Up Reports	1.42		1.20	1.70
115	Communicate and Report	0090	FLEXIBILITY OF CLOSURE	10-Call to Conference	0.00		1.20	0.00
116	Communicate and Report	0090	FLEXIBILITY OF CLOSURE	26-Receive Digital Message	0.00		1.20	0.00
117	Communicate and Report	0090	FLEXIBILITY OF CLOSURE	27-Input data Into Computer	0.00		1.20	0.00
118	Communicate and Report	0090	FLEXIBILITY OF CLOSURE	28-Send Digital Information	0.00		1.20	0.00
119	Communicate and Report	0100	SELECTIVE ATTENTION	01-Receive and Record/Analog	1.50		1.20	1.80
120	Communicate and Report	0100	SELECTIVE ATTENTION	02-Pass Information	1.50		1.20	1.80
121	Communicate and Report	0100	SELECTIVE ATTENTION	03-Listen-Receive Information	1.50		1.20	1.80
122	Communicate and Report	0100	SELECTIVE ATTENTION	04-Secondary Monitor	1.50		1.20	1.80
123	Communicate and Report	0100	SELECTIVE ATTENTION	05-Log Message	1.50		1.20	1.80
124	Communicate and Report	0100	SELECTIVE ATTENTION	06-Route (Outside the Section)	0.00		1.20	0.00
125	Communicate and Report	0100	SELECTIVE ATTENTION	07-Send Message	1.50		1.20	1.80
126	Communicate and Report	0100	SELECTIVE ATTENTION	08-Verbal Order	1.50		1.20	1.80
127	Communicate and Report	0100	SELECTIVE ATTENTION	09-Roll Up Reports	1.50		1.20	1.80
128	Communicate and Report	0100	SELECTIVE ATTENTION	10-Call to Conference	0.00		1.20	0.00
129	Communicate and Report	0100	SELECTIVE ATTENTION	26-Receive Digital Message	1.50		1.20	1.80
130	Communicate and Report	0100	SELECTIVE ATTENTION	27-Input data Into Computer	1.50		1.20	1.80
131	Communicate and Report	0100	SELECTIVE ATTENTION	28-Send Digital Information	1.50		1.20	1.80
132	Communicate and Report	0110	SPATIAL ORIENTATION	01-Receive and Record/Analog	0.00		1.20	0.00
133	Communicate and Report	0110	SPATIAL ORIENTATION	02-Pass Information	0.00		1.20	0.00
134	Communicate and Report	0110	SPATIAL ORIENTATION	03-Listen-Receive Information	0.00		1.20	0.00
135	Communicate and Report	0110	SPATIAL ORIENTATION	04-Secondary Monitor	0.00		1.20	0.00
136	Communicate and Report	0110	SPATIAL ORIENTATION	05-Log Message	0.00		1.20	0.00
137	Communicate and Report	0110	SPATIAL ORIENTATION	06-Route (Outside the Section)	0.00		1.20	0.00
138	Communicate and Report	0110	SPATIAL ORIENTATION	07-Send Message	0.00		1.20	0.00
139	Communicate and Report	0110	SPATIAL ORIENTATION	08-Verbal Order	0.00		1.20	0.00
140	Communicate and Report	0110	SPATIAL ORIENTATION	09-Roll Up Reports	0.00		1.20	0.00
141	Communicate and Report	0110	SPATIAL ORIENTATION	10-Call to Conference	0.00		1.20	0.00
142	Communicate and Report	0110	SPATIAL ORIENTATION	26-Receive Digital Message	0.00		1.20	0.00
143	Communicate and Report	0110	SPATIAL ORIENTATION	27-Input data Into Computer	0.00		1.20	0.00
144	Communicate and Report	0110	SPATIAL ORIENTATION	28-Send Digital Information	0.00		1.20	0.00
145	Communicate and Report	0120	VISUALIZATION	01-Receive and Record/Analog	0.00		1.20	0.00
146	Communicate and Report	0120	VISUALIZATION	02-Pass Information	0.00		1.20	0.00
147	Communicate and Report	0120	VISUALIZATION	03-Listen-Receive Information	0.00		1.20	0.00
148	Communicate and Report	0120	VISUALIZATION	04-Secondary Monitor	0.00		1.20	0.00
149	Communicate and Report	0120	VISUALIZATION	05-Log Message	0.00		1.20	0.00
150	Communicate and Report	0120	VISUALIZATION	06-Route (Outside the Section)	0.00		1.20	0.00
151	Communicate and Report	0120	VISUALIZATION	07-Send Message	0.00		1.20	0.00
152	Communicate and Report	0120	VISUALIZATION	08-Verbal Order	0.00		1.20	0.00
153	Communicate and Report	0120	VISUALIZATION	09-Roll Up Reports	0.00		1.20	0.00
154	Communicate and Report	0120	VISUALIZATION	10-Call to Conference	0.00		1.20	0.00
155	Communicate and Report	0120	VISUALIZATION	26-Receive Digital Message	0.00		1.20	0.00
156	Communicate and Report	0120	VISUALIZATION	27-Input data Into Computer	0.00		1.20	0.00
157	Communicate and Report	0120	VISUALIZATION	28-Send Digital Information	0.00		1.20	0.00
158	Communicate and Report	0130	INDUCTIVE REASONING	01-Receive and Record/Analog	0.00		1.20	0.00
159	Communicate and Report	0130	INDUCTIVE REASONING	02-Pass Information	0.00		1.20	0.00
160	Communicate and Report	0130	INDUCTIVE REASONING	03-Listen-Receive Information	0.00		1.20	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
161	Communicate and Report	0130	INDUCTIVE REASONING	04-Secondary Monitor	0.00		1.20	0.00
162	Communicate and Report	0130	INDUCTIVE REASONING	05-Log Message	0.00		1.20	0.00
163	Communicate and Report	0130	INDUCTIVE REASONING	06-Route (Outside the Section)	0.00		1.20	0.00
164	Communicate and Report	0130	INDUCTIVE REASONING	07-Send Message	0.00		1.20	0.00
165	Communicate and Report	0130	INDUCTIVE REASONING	08-Verbal Order	0.00		1.20	0.00
166	Communicate and Report	0130	INDUCTIVE REASONING	09-Roll Up Reports	0.00		1.20	0.00
167	Communicate and Report	0130	INDUCTIVE REASONING	10-Call to Conference	0.00		1.20	0.00
168	Communicate and Report	0130	INDUCTIVE REASONING	26-Receive Digital Message	0.00		1.20	0.00
169	Communicate and Report	0130	INDUCTIVE REASONING	27-Input data Into Computer	0.00		1.20	0.00
170	Communicate and Report	0130	INDUCTIVE REASONING	28-Send Digital Information	0.00		1.20	0.00
171	Communicate and Report	0140	CATEGORY FLEXIBILITY	01-Receive and Record/Analog	0.00		1.20	0.00
172	Communicate and Report	0140	CATEGORY FLEXIBILITY	02-Pass Information	0.00		1.20	0.00
173	Communicate and Report	0140	CATEGORY FLEXIBILITY	03-Listen-Receive Information	0.00		1.20	0.00
174	Communicate and Report	0140	CATEGORY FLEXIBILITY	04-Secondary Monitor	0.00		1.20	0.00
175	Communicate and Report	0140	CATEGORY FLEXIBILITY	05-Log Message	0.00		1.20	0.00
176	Communicate and Report	0140	CATEGORY FLEXIBILITY	06-Route (Outside the Section)	0.00		1.20	0.00
177	Communicate and Report	0140	CATEGORY FLEXIBILITY	07-Send Message	0.00		1.20	0.00
178	Communicate and Report	0140	CATEGORY FLEXIBILITY	08-Verbal Order	0.00		1.20	0.00
179	Communicate and Report	0140	CATEGORY FLEXIBILITY	09-Roll Up Reports	0.00		1.20	0.00
180	Communicate and Report	0140	CATEGORY FLEXIBILITY	10-Call to Conference	0.00		1.20	0.00
181	Communicate and Report	0140	CATEGORY FLEXIBILITY	26-Receive Digital Message	0.00		1.20	0.00
182	Communicate and Report	0140	CATEGORY FLEXIBILITY	27-Input data Into Computer	0.00		1.20	0.00
183	Communicate and Report	0140	CATEGORY FLEXIBILITY	28-Send Digital Information	0.00		1.20	0.00
184	Communicate and Report	0150	DEDUCTIVE REASONING	01-Receive and Record/Analog	0.00		1.20	0.00
185	Communicate and Report	0150	DEDUCTIVE REASONING	02-Pass Information	0.00		1.20	0.00
186	Communicate and Report	0150	DEDUCTIVE REASONING	03-Listen-Receive Information	0.00		1.20	0.00
187	Communicate and Report	0150	DEDUCTIVE REASONING	04-Secondary Monitor	0.00		1.20	0.00
188	Communicate and Report	0150	DEDUCTIVE REASONING	05-Log Message	0.00		1.20	0.00
189	Communicate and Report	0150	DEDUCTIVE REASONING	06-Route (Outside the Section)	0.00		1.20	0.00
190	Communicate and Report	0150	DEDUCTIVE REASONING	07-Send Message	0.00		1.20	0.00
191	Communicate and Report	0150	DEDUCTIVE REASONING	08-Verbal Order	0.00		1.20	0.00
192	Communicate and Report	0150	DEDUCTIVE REASONING	09-Roll Up Reports	0.00		1.20	0.00
193	Communicate and Report	0150	DEDUCTIVE REASONING	10-Call to Conference	0.00		1.20	0.00
194	Communicate and Report	0150	DEDUCTIVE REASONING	26-Receive Digital Message	0.00		1.20	0.00
195	Communicate and Report	0150	DEDUCTIVE REASONING	27-Input data Into Computer	0.00		1.20	0.00
196	Communicate and Report	0150	DEDUCTIVE REASONING	28-Send Digital Information	0.00		1.20	0.00
197	Communicate and Report	0160	INFORMATION ORDERING	01-Receive and Record/Analog	0.00		1.20	0.00
198	Communicate and Report	0160	INFORMATION ORDERING	02-Pass Information	0.00		1.20	0.00
199	Communicate and Report	0160	INFORMATION ORDERING	03-Listen-Receive Information	0.00		1.20	0.00
200	Communicate and Report	0160	INFORMATION ORDERING	04-Secondary Monitor	0.00		1.20	0.00
201	Communicate and Report	0160	INFORMATION ORDERING	05-Log Message	0.00		1.20	0.00
202	Communicate and Report	0160	INFORMATION ORDERING	06-Route (Outside the Section)	0.00		1.20	0.00
203	Communicate and Report	0160	INFORMATION ORDERING	07-Send Message	0.00		1.20	0.00
204	Communicate and Report	0160	INFORMATION ORDERING	08-Verbal Order	0.00		1.20	0.00
205	Communicate and Report	0160	INFORMATION ORDERING	09-Roll Up Reports	3.08		1.20	3.70
206	Communicate and Report	0160	INFORMATION ORDERING	10-Call to Conference	0.00		1.20	0.00
207	Communicate and Report	0160	INFORMATION ORDERING	26-Receive Digital Message	0.00		1.20	0.00
208	Communicate and Report	0160	INFORMATION ORDERING	27-Input data Into Computer	0.00		1.20	0.00
209	Communicate and Report	0160	INFORMATION ORDERING	28-Send Digital Information	0.00		1.20	0.00
210	Communicate and Report	0170	MATHEMATICAL REASONI	01-Receive and Record/Analog	0.00		1.20	0.00
211	Communicate and Report	0170	MATHEMATICAL REASONI	02-Pass Information	0.00		1.20	0.00
212	Communicate and Report	0170	MATHEMATICAL REASONI	03-Listen-Receive Information	0.00		1.20	0.00
213	Communicate and Report	0170	MATHEMATICAL REASONI	04-Secondary Monitor	0.00		1.20	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
214	Communicate and Report	0170	MATHEMATICAL REASONI	05-Log Message	0.00		1.20	0.00
215	Communicate and Report	0170	MATHEMATICAL REASONI	06-Route (Outside the Section)	0.00		1.20	0.00
216	Communicate and Report	0170	MATHEMATICAL REASONI	07-Send Message	0.00		1.20	0.00
217	Communicate and Report	0170	MATHEMATICAL REASONI	08-Verbal Order	0.00		1.20	0.00
218	Communicate and Report	0170	MATHEMATICAL REASONI	09-Roll Up Reports	2.00		1.20	2.40
219	Communicate and Report	0170	MATHEMATICAL REASONI	10-Call to Conference	0.00		1.20	0.00
220	Communicate and Report	0170	MATHEMATICAL REASONI	26-Receive Digital Message	0.00		1.20	0.00
221	Communicate and Report	0170	MATHEMATICAL REASONI	27-Input data Into Computer	0.00		1.20	0.00
222	Communicate and Report	0170	MATHEMATICAL REASONI	28-Send Digital Information	0.00		1.20	0.00
223	Communicate and Report	0180	NUMBER FACILITY	01-Receive and Record/Analog	0.00		1.20	0.00
224	Communicate and Report	0180	NUMBER FACILITY	02-Pass Information	0.00		1.20	0.00
225	Communicate and Report	0180	NUMBER FACILITY	03-Listen-Receive Information	0.00		1.20	0.00
226	Communicate and Report	0180	NUMBER FACILITY	04-Secondary Monitor	0.00		1.20	0.00
227	Communicate and Report	0180	NUMBER FACILITY	05-Log Message	0.00		1.20	0.00
228	Communicate and Report	0180	NUMBER FACILITY	06-Route (Outside the Section)	0.00		1.20	0.00
229	Communicate and Report	0180	NUMBER FACILITY	07-Send Message	0.00		1.20	0.00
230	Communicate and Report	0180	NUMBER FACILITY	08-Verbal Order	0.00		1.20	0.00
231	Communicate and Report	0180	NUMBER FACILITY	09-Roll Up Reports	2.50		1.20	3.00
232	Communicate and Report	0180	NUMBER FACILITY	10-Call to Conference	0.00		1.20	0.00
233	Communicate and Report	0180	NUMBER FACILITY	26-Receive Digital Message	0.00		1.20	0.00
234	Communicate and Report	0180	NUMBER FACILITY	27-Input data Into Computer	0.00		1.20	0.00
235	Communicate and Report	0180	NUMBER FACILITY	28-Send Digital Information	0.00		1.20	0.00
236	Communicate and Report	0190	TIME SHARING	01-Receive and Record/Analog	2.00		1.20	2.40
237	Communicate and Report	0190	TIME SHARING	02-Pass Information	0.00		1.20	0.00
238	Communicate and Report	0190	TIME SHARING	03-Listen-Receive Information	0.00		1.20	0.00
239	Communicate and Report	0190	TIME SHARING	04-Secondary Monitor	2.00		1.20	2.40
240	Communicate and Report	0190	TIME SHARING	05-Log Message	0.00		1.20	0.00
241	Communicate and Report	0190	TIME SHARING	06-Route (Outside the Section)	0.00		1.20	0.00
242	Communicate and Report	0190	TIME SHARING	07-Send Message	0.00		1.20	0.00
243	Communicate and Report	0190	TIME SHARING	08-Verbal Order	0.00		1.20	0.00
244	Communicate and Report	0190	TIME SHARING	09-Roll Up Reports	0.00		1.20	0.00
245	Communicate and Report	0190	TIME SHARING	10-Call to Conference	0.00		1.20	0.00
246	Communicate and Report	0190	TIME SHARING	26-Receive Digital Message	2.00		1.20	2.40
247	Communicate and Report	0190	TIME SHARING	27-Input data Into Computer	2.00		1.20	2.40
248	Communicate and Report	0190	TIME SHARING	28-Send Digital Information	2.00		1.20	2.40
249	Communicate and Report	0200	SPEED OF CLOSURE	01-Receive and Record/Analog	0.00		1.20	0.00
250	Communicate and Report	0200	SPEED OF CLOSURE	02-Pass Information	0.00		1.20	0.00
251	Communicate and Report	0200	SPEED OF CLOSURE	03-Listen-Receive Information	0.00		1.20	0.00
252	Communicate and Report	0200	SPEED OF CLOSURE	04-Secondary Monitor	0.00		1.20	0.00
253	Communicate and Report	0200	SPEED OF CLOSURE	05-Log Message	0.00		1.20	0.00
254	Communicate and Report	0200	SPEED OF CLOSURE	06-Route (Outside the Section)	0.00		1.20	0.00
255	Communicate and Report	0200	SPEED OF CLOSURE	07-Send Message	0.00		1.20	0.00
256	Communicate and Report	0200	SPEED OF CLOSURE	08-Verbal Order	0.00		1.20	0.00
257	Communicate and Report	0200	SPEED OF CLOSURE	09-Roll Up Reports	0.00		1.20	0.00
258	Communicate and Report	0200	SPEED OF CLOSURE	10-Call to Conference	0.00		1.20	0.00
259	Communicate and Report	0200	SPEED OF CLOSURE	26-Receive Digital Message	0.00		1.20	0.00
260	Communicate and Report	0200	SPEED OF CLOSURE	27-Input data Into Computer	0.00		1.20	0.00
261	Communicate and Report	0200	SPEED OF CLOSURE	28-Send Digital Information	0.00		1.20	0.00
262	Communicate and Report	0210	PERCEPTUAL SPEED AND	01-Receive and Record/Analog	0.00		1.20	0.00
263	Communicate and Report	0210	PERCEPTUAL SPEED AND	02-Pass Information	0.00		1.20	0.00
264	Communicate and Report	0210	PERCEPTUAL SPEED AND	03-Listen-Receive Information	0.00		1.20	0.00
265	Communicate and Report	0210	PERCEPTUAL SPEED AND	04-Secondary Monitor	0.00		1.20	0.00
266	Communicate and Report	0210	PERCEPTUAL SPEED AND	05-Log Message	0.00		1.20	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
267	Communicate and Report	0210	PERCEPTUAL SPEED AND	06-Route (Outside the Section)	0.00		1.20	0.00
268	Communicate and Report	0210	PERCEPTUAL SPEED AND	07-Send Message	0.00		1.20	0.00
269	Communicate and Report	0210	PERCEPTUAL SPEED AND	08-Verbal Order	0.00		1.20	0.00
270	Communicate and Report	0210	PERCEPTUAL SPEED AND	09-Roll Up Reports	2.38		1.20	2.86
271	Communicate and Report	0210	PERCEPTUAL SPEED AND	10-Call to Conference	0.00		1.20	0.00
272	Communicate and Report	0210	PERCEPTUAL SPEED AND	26-Receive Digital Message	0.00		1.20	0.00
273	Communicate and Report	0210	PERCEPTUAL SPEED AND	27-Input data Into Computer	0.00		1.20	0.00
274	Communicate and Report	0210	PERCEPTUAL SPEED AND	28-Send Digital Information	0.00		1.20	0.00
275	Communicate and Report	0220	REACTION TIME	01-Receive and Record/Analog	0.00		1.20	0.00
276	Communicate and Report	0220	REACTION TIME	02-Pass Information	0.00		1.20	0.00
277	Communicate and Report	0220	REACTION TIME	03-Listen-Receive Information	0.00		1.20	0.00
278	Communicate and Report	0220	REACTION TIME	04-Secondary Monitor	0.00		1.20	0.00
279	Communicate and Report	0220	REACTION TIME	05-Log Message	0.00		1.20	0.00
280	Communicate and Report	0220	REACTION TIME	06-Route (Outside the Section)	0.00		1.20	0.00
281	Communicate and Report	0220	REACTION TIME	07-Send Message	0.00		1.20	0.00
282	Communicate and Report	0220	REACTION TIME	08-Verbal Order	0.00		1.20	0.00
283	Communicate and Report	0220	REACTION TIME	09-Roll Up Reports	0.00		1.20	0.00
284	Communicate and Report	0220	REACTION TIME	10-Call to Conference	0.00		1.20	0.00
285	Communicate and Report	0220	REACTION TIME	26-Receive Digital Message	0.00		1.20	0.00
286	Communicate and Report	0220	REACTION TIME	27-Input data Into Computer	0.00		1.20	0.00
287	Communicate and Report	0220	REACTION TIME	28-Send Digital Information	0.00		1.20	0.00
288	Communicate and Report	0230	CHOICE REACTION TIME	01-Receive and Record/Analog	0.00		1.20	0.00
289	Communicate and Report	0230	CHOICE REACTION TIME	02-Pass Information	0.00		1.20	0.00
290	Communicate and Report	0230	CHOICE REACTION TIME	03-Listen-Receive Information	0.00		1.20	0.00
291	Communicate and Report	0230	CHOICE REACTION TIME	04-Secondary Monitor	0.00		1.20	0.00
292	Communicate and Report	0230	CHOICE REACTION TIME	05-Log Message	0.00		1.20	0.00
293	Communicate and Report	0230	CHOICE REACTION TIME	06-Route (Outside the Section)	0.00		1.20	0.00
294	Communicate and Report	0230	CHOICE REACTION TIME	07-Send Message	0.00		1.20	0.00
295	Communicate and Report	0230	CHOICE REACTION TIME	08-Verbal Order	0.00		1.20	0.00
296	Communicate and Report	0230	CHOICE REACTION TIME	09-Roll Up Reports	0.00		1.20	0.00
297	Communicate and Report	0230	CHOICE REACTION TIME	10-Call to Conference	0.00		1.20	0.00
298	Communicate and Report	0230	CHOICE REACTION TIME	26-Receive Digital Message	0.00		1.20	0.00
299	Communicate and Report	0230	CHOICE REACTION TIME	27-Input data Into Computer	0.00		1.20	0.00
300	Communicate and Report	0230	CHOICE REACTION TIME	28-Send Digital Information	0.00		1.20	0.00
301	Communicate and Report	0240	NEAR VISION	01-Receive and Record/Analog	1.26		1.20	1.51
302	Communicate and Report	0240	NEAR VISION	02-Pass Information	1.26		1.20	1.51
303	Communicate and Report	0240	NEAR VISION	03-Listen-Receive Information	1.26		1.20	1.51
304	Communicate and Report	0240	NEAR VISION	04-Secondary Monitor	1.26		1.20	1.51
305	Communicate and Report	0240	NEAR VISION	05-Log Message	1.26		1.20	1.51
306	Communicate and Report	0240	NEAR VISION	06-Route (Outside the Section)	0.00		1.20	0.00
307	Communicate and Report	0240	NEAR VISION	07-Send Message	1.26		1.20	1.51
308	Communicate and Report	0240	NEAR VISION	08-Verbal Order	1.26		1.20	1.51
309	Communicate and Report	0240	NEAR VISION	09-Roll Up Reports	1.26		1.20	1.51
310	Communicate and Report	0240	NEAR VISION	10-Call to Conference	0.00		1.20	0.00
311	Communicate and Report	0240	NEAR VISION	26-Receive Digital Message	1.26		1.20	1.51
312	Communicate and Report	0240	NEAR VISION	27-Input data Into Computer	1.26		1.20	1.51
313	Communicate and Report	0240	NEAR VISION	28-Send Digital Information	1.26		1.20	1.51
314	Communicate and Report	0250	FAR VISION	01-Receive and Record/Analog	0.00		1.20	0.00
315	Communicate and Report	0250	FAR VISION	02-Pass Information	0.00		1.20	0.00
316	Communicate and Report	0250	FAR VISION	03-Listen-Receive Information	0.00		1.20	0.00
317	Communicate and Report	0250	FAR VISION	04-Secondary Monitor	0.00		1.20	0.00
318	Communicate and Report	0250	FAR VISION	05-Log Message	0.00		1.20	0.00
319	Communicate and Report	0250	FAR VISION	06-Route (Outside the Section)	1.50		1.20	1.80

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
320	Communicate and Report	0250	FAR VISION	07-Send Message	0.00		1.20	0.00
321	Communicate and Report	0250	FAR VISION	08-Verbal Order	0.00		1.20	0.00
322	Communicate and Report	0250	FAR VISION	09-Roll Up Reports	0.00		1.20	0.00
323	Communicate and Report	0250	FAR VISION	10-Call to Conference	0.00		1.20	0.00
324	Communicate and Report	0250	FAR VISION	26-Receive Digital Message	0.00		1.20	0.00
325	Communicate and Report	0250	FAR VISION	27-Input data Into Computer	0.00		1.20	0.00
326	Communicate and Report	0250	FAR VISION	28-Send Digital Information	0.00		1.20	0.00
327	Communicate and Report	0260	NIGHT VISION	01-Receive and Record/Analog	0.00		1.20	0.00
328	Communicate and Report	0260	NIGHT VISION	02-Pass Information	0.00		1.20	0.00
329	Communicate and Report	0260	NIGHT VISION	03-Listen-Receive Information	0.00		1.20	0.00
330	Communicate and Report	0260	NIGHT VISION	04-Secondary Monitor	0.00		1.20	0.00
331	Communicate and Report	0260	NIGHT VISION	05-Log Message	0.00		1.20	0.00
332	Communicate and Report	0260	NIGHT VISION	06-Route (Outside the Section)	0.00		1.20	0.00
333	Communicate and Report	0260	NIGHT VISION	07-Send Message	0.00		1.20	0.00
334	Communicate and Report	0260	NIGHT VISION	08-Verbal Order	0.00		1.20	0.00
335	Communicate and Report	0260	NIGHT VISION	09-Roll Up Reports	0.00		1.20	0.00
336	Communicate and Report	0260	NIGHT VISION	10-Call to Conference	0.00		1.20	0.00
337	Communicate and Report	0260	NIGHT VISION	26-Receive Digital Message	0.00		1.20	0.00
338	Communicate and Report	0260	NIGHT VISION	27-Input data Into Computer	0.00		1.20	0.00
339	Communicate and Report	0260	NIGHT VISION	28-Send Digital Information	0.00		1.20	0.00
340	Communicate and Report	0270	VISUAL COLOR DISCRIMIN	01-Receive and Record/Analog	0.00		1.20	0.00
341	Communicate and Report	0270	VISUAL COLOR DISCRIMIN	02-Pass Information	0.00		1.20	0.00
342	Communicate and Report	0270	VISUAL COLOR DISCRIMIN	03-Listen-Receive Information	0.00		1.20	0.00
343	Communicate and Report	0270	VISUAL COLOR DISCRIMIN	04-Secondary Monitor	0.00		1.20	0.00
344	Communicate and Report	0270	VISUAL COLOR DISCRIMIN	05-Log Message	0.00		1.20	0.00
345	Communicate and Report	0270	VISUAL COLOR DISCRIMIN	06-Route (Outside the Section)	0.00		1.20	0.00
346	Communicate and Report	0270	VISUAL COLOR DISCRIMIN	07-Send Message	0.00		1.20	0.00
347	Communicate and Report	0270	VISUAL COLOR DISCRIMIN	08-Verbal Order	0.00		1.20	0.00
348	Communicate and Report	0270	VISUAL COLOR DISCRIMIN	09-Roll Up Reports	0.00		1.20	0.00
349	Communicate and Report	0270	VISUAL COLOR DISCRIMIN	10-Call to Conference	0.00		1.20	0.00
350	Communicate and Report	0270	VISUAL COLOR DISCRIMIN	26-Receive Digital Message	0.00		1.20	0.00
351	Communicate and Report	0270	VISUAL COLOR DISCRIMIN	27-Input data Into Computer	1.50		1.20	1.80
352	Communicate and Report	0270	VISUAL COLOR DISCRIMIN	28-Send Digital Information	1.50		1.20	1.80
353	Communicate and Report	0280	PERIPHERAL VISION	01-Receive and Record/Analog	0.00		1.20	0.00
354	Communicate and Report	0280	PERIPHERAL VISION	02-Pass Information	0.00		1.20	0.00
355	Communicate and Report	0280	PERIPHERAL VISION	03-Listen-Receive Information	0.00		1.20	0.00
356	Communicate and Report	0280	PERIPHERAL VISION	04-Secondary Monitor	0.00		1.20	0.00
357	Communicate and Report	0280	PERIPHERAL VISION	05-Log Message	0.00		1.20	0.00
358	Communicate and Report	0280	PERIPHERAL VISION	06-Route (Outside the Section)	0.00		1.20	0.00
359	Communicate and Report	0280	PERIPHERAL VISION	07-Send Message	0.00		1.20	0.00
360	Communicate and Report	0280	PERIPHERAL VISION	08-Verbal Order	0.00		1.20	0.00
361	Communicate and Report	0280	PERIPHERAL VISION	09-Roll Up Reports	0.00		1.20	0.00
362	Communicate and Report	0280	PERIPHERAL VISION	10-Call to Conference	0.00		1.20	0.00
363	Communicate and Report	0280	PERIPHERAL VISION	26-Receive Digital Message	0.00		1.20	0.00
364	Communicate and Report	0280	PERIPHERAL VISION	27-Input data Into Computer	0.00		1.20	0.00
365	Communicate and Report	0280	PERIPHERAL VISION	28-Send Digital Information	0.00		1.20	0.00
366	Communicate and Report	0290	DEPTH PERCEPTION	01-Receive and Record/Analog	0.00		1.20	0.00
367	Communicate and Report	0290	DEPTH PERCEPTION	02-Pass Information	0.00		1.20	0.00
368	Communicate and Report	0290	DEPTH PERCEPTION	03-Listen-Receive Information	0.00		1.20	0.00
369	Communicate and Report	0290	DEPTH PERCEPTION	04-Secondary Monitor	0.00		1.20	0.00
370	Communicate and Report	0290	DEPTH PERCEPTION	05-Log Message	0.00		1.20	0.00
371	Communicate and Report	0290	DEPTH PERCEPTION	06-Route (Outside the Section)	1.00		1.20	1.20
372	Communicate and Report	0290	DEPTH PERCEPTION	07-Send Message	0.00		1.20	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
373	Communicate and Report	0290	DEPTH PERCEPTION	08-Verbal Order	0.00		1.20	0.00
374	Communicate and Report	0290	DEPTH PERCEPTION	09-Roll Up Reports	0.00		1.20	0.00
375	Communicate and Report	0290	DEPTH PERCEPTION	10-Call to Conference	0.00		1.20	0.00
376	Communicate and Report	0290	DEPTH PERCEPTION	26-Receive Digital Message	0.00		1.20	0.00
377	Communicate and Report	0290	DEPTH PERCEPTION	27-Input data Into Computer	0.00		1.20	0.00
378	Communicate and Report	0290	DEPTH PERCEPTION	28-Send Digital Information	0.00		1.20	0.00
379	Communicate and Report	0300	GLARE SENSITIVITY	01-Receive and Record/Analog	0.00		1.20	0.00
380	Communicate and Report	0300	GLARE SENSITIVITY	02-Pass Information	0.00		1.20	0.00
381	Communicate and Report	0300	GLARE SENSITIVITY	03-Listen-Receive Information	0.00		1.20	0.00
382	Communicate and Report	0300	GLARE SENSITIVITY	04-Secondary Monitor	0.00		1.20	0.00
383	Communicate and Report	0300	GLARE SENSITIVITY	05-Log Message	0.00		1.20	0.00
384	Communicate and Report	0300	GLARE SENSITIVITY	06-Route (Outside the Section)	0.00		1.20	0.00
385	Communicate and Report	0300	GLARE SENSITIVITY	07-Send Message	0.00		1.20	0.00
386	Communicate and Report	0300	GLARE SENSITIVITY	08-Verbal Order	0.00		1.20	0.00
387	Communicate and Report	0300	GLARE SENSITIVITY	09-Roll Up Reports	0.00		1.20	0.00
388	Communicate and Report	0300	GLARE SENSITIVITY	10-Call to Conference	0.00		1.20	0.00
389	Communicate and Report	0300	GLARE SENSITIVITY	26-Receive Digital Message	0.00		1.20	0.00
390	Communicate and Report	0300	GLARE SENSITIVITY	27-Input data Into Computer	0.00		1.20	0.00
391	Communicate and Report	0300	GLARE SENSITIVITY	28-Send Digital Information	0.00		1.20	0.00
392	Communicate and Report	0310	GENERAL HEARING	01-Receive and Record/Analog	0.00		1.20	0.00
393	Communicate and Report	0310	GENERAL HEARING	02-Pass Information	0.00		1.20	0.00
394	Communicate and Report	0310	GENERAL HEARING	03-Listen-Receive Information	0.00		1.20	0.00
395	Communicate and Report	0310	GENERAL HEARING	04-Secondary Monitor	0.00		1.20	0.00
396	Communicate and Report	0310	GENERAL HEARING	05-Log Message	0.00		1.20	0.00
397	Communicate and Report	0310	GENERAL HEARING	06-Route (Outside the Section)	0.00		1.20	0.00
398	Communicate and Report	0310	GENERAL HEARING	07-Send Message	0.00		1.20	0.00
399	Communicate and Report	0310	GENERAL HEARING	08-Verbal Order	0.00		1.20	0.00
400	Communicate and Report	0310	GENERAL HEARING	09-Roll Up Reports	0.00		1.20	0.00
401	Communicate and Report	0310	GENERAL HEARING	10-Call to Conference	0.00		1.20	0.00
402	Communicate and Report	0310	GENERAL HEARING	26-Receive Digital Message	0.00		1.20	0.00
403	Communicate and Report	0310	GENERAL HEARING	27-Input data Into Computer	0.00		1.20	0.00
404	Communicate and Report	0310	GENERAL HEARING	28-Send Digital Information	0.00		1.20	0.00
405	Communicate and Report	0320	AUDITORY ATTENTION	01-Receive and Record/Analog	1.97		1.20	2.36
406	Communicate and Report	0320	AUDITORY ATTENTION	02-Pass Information	0.00		1.20	0.00
407	Communicate and Report	0320	AUDITORY ATTENTION	03-Listen-Receive Information	1.97		1.20	2.36
408	Communicate and Report	0320	AUDITORY ATTENTION	04-Secondary Monitor	1.97		1.20	2.36
409	Communicate and Report	0320	AUDITORY ATTENTION	05-Log Message	0.00		1.20	0.00
410	Communicate and Report	0320	AUDITORY ATTENTION	06-Route (Outside the Section)	0.00		1.20	0.00
411	Communicate and Report	0320	AUDITORY ATTENTION	07-Send Message	0.00		1.20	0.00
412	Communicate and Report	0320	AUDITORY ATTENTION	08-Verbal Order	0.00		1.20	0.00
413	Communicate and Report	0320	AUDITORY ATTENTION	09-Roll Up Reports	0.00		1.20	0.00
414	Communicate and Report	0320	AUDITORY ATTENTION	10-Call to Conference	1.97		1.20	2.36
415	Communicate and Report	0320	AUDITORY ATTENTION	26-Receive Digital Message	1.97		1.20	2.36
416	Communicate and Report	0320	AUDITORY ATTENTION	27-Input data Into Computer	0.00		1.20	0.00
417	Communicate and Report	0320	AUDITORY ATTENTION	28-Send Digital Information	0.00		1.20	0.00
418	Communicate and Report	0330	SOUND LOCALIZATION	01-Receive and Record/Analog	0.00		1.20	0.00
419	Communicate and Report	0330	SOUND LOCALIZATION	02-Pass Information	0.00		1.20	0.00
420	Communicate and Report	0330	SOUND LOCALIZATION	03-Listen-Receive Information	0.00		1.20	0.00
421	Communicate and Report	0330	SOUND LOCALIZATION	04-Secondary Monitor	0.00		1.20	0.00
422	Communicate and Report	0330	SOUND LOCALIZATION	05-Log Message	0.00		1.20	0.00
423	Communicate and Report	0330	SOUND LOCALIZATION	06-Route (Outside the Section)	0.00		1.20	0.00
424	Communicate and Report	0330	SOUND LOCALIZATION	07-Send Message	0.00		1.20	0.00
425	Communicate and Report	0330	SOUND LOCALIZATION	08-Verbal Order	0.00		1.20	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
426	Communicate and Report	0330	SOUND LOCALIZATION	09-Roll Up Reports	0.00		1.20	0.00
427	Communicate and Report	0330	SOUND LOCALIZATION	10-Call to Conference	0.00		1.20	0.00
428	Communicate and Report	0330	SOUND LOCALIZATION	26-Receive Digital Message	0.00		1.20	0.00
429	Communicate and Report	0330	SOUND LOCALIZATION	27-Input data Into Computer	0.00		1.20	0.00
430	Communicate and Report	0330	SOUND LOCALIZATION	28-Send Digital Information	0.00		1.20	0.00
431	Communicate and Report	0340	CONTROL PRECISION	01-Receive and Record/Analog	0.00		1.20	0.00
432	Communicate and Report	0340	CONTROL PRECISION	02-Pass Information	0.00		1.20	0.00
433	Communicate and Report	0340	CONTROL PRECISION	03-Listen-Receive Information	0.00		1.20	0.00
434	Communicate and Report	0340	CONTROL PRECISION	04-Secondary Monitor	0.00		1.20	0.00
435	Communicate and Report	0340	CONTROL PRECISION	05-Log Message	0.00		1.20	0.00
436	Communicate and Report	0340	CONTROL PRECISION	06-Route (Outside the Section)	0.00		1.20	0.00
437	Communicate and Report	0340	CONTROL PRECISION	07-Send Message	0.00		1.20	0.00
438	Communicate and Report	0340	CONTROL PRECISION	08-Verbal Order	0.00		1.20	0.00
439	Communicate and Report	0340	CONTROL PRECISION	09-Roll Up Reports	0.00		1.20	0.00
440	Communicate and Report	0340	CONTROL PRECISION	10-Call to Conference	0.00		1.20	0.00
441	Communicate and Report	0340	CONTROL PRECISION	26-Receive Digital Message	0.00		1.20	0.00
442	Communicate and Report	0340	CONTROL PRECISION	27-Input data Into Computer	0.00		1.20	0.00
443	Communicate and Report	0340	CONTROL PRECISION	28-Send Digital Information	0.00		1.20	0.00
444	Communicate and Report	0350	RATE CONTROL	01-Receive and Record/Analog	0.00		1.20	0.00
445	Communicate and Report	0350	RATE CONTROL	02-Pass Information	0.00		1.20	0.00
446	Communicate and Report	0350	RATE CONTROL	03-Listen-Receive Information	0.00		1.20	0.00
447	Communicate and Report	0350	RATE CONTROL	04-Secondary Monitor	0.00		1.20	0.00
448	Communicate and Report	0350	RATE CONTROL	05-Log Message	0.00		1.20	0.00
449	Communicate and Report	0350	RATE CONTROL	06-Route (Outside the Section)	0.00		1.20	0.00
450	Communicate and Report	0350	RATE CONTROL	07-Send Message	0.00		1.20	0.00
451	Communicate and Report	0350	RATE CONTROL	08-Verbal Order	0.00		1.20	0.00
452	Communicate and Report	0350	RATE CONTROL	09-Roll Up Reports	0.00		1.20	0.00
453	Communicate and Report	0350	RATE CONTROL	10-Call to Conference	0.00		1.20	0.00
454	Communicate and Report	0350	RATE CONTROL	26-Receive Digital Message	0.00		1.20	0.00
455	Communicate and Report	0350	RATE CONTROL	27-Input data Into Computer	0.00		1.20	0.00
456	Communicate and Report	0350	RATE CONTROL	28-Send Digital Information	0.00		1.20	0.00
457	Communicate and Report	0360	WRIST-FINGER SPEED	01-Receive and Record/Analog	0.00		1.20	0.00
458	Communicate and Report	0360	WRIST-FINGER SPEED	02-Pass Information	0.00		1.20	0.00
459	Communicate and Report	0360	WRIST-FINGER SPEED	03-Listen-Receive Information	0.00		1.20	0.00
460	Communicate and Report	0360	WRIST-FINGER SPEED	04-Secondary Monitor	0.00		1.20	0.00
461	Communicate and Report	0360	WRIST-FINGER SPEED	05-Log Message	0.00		1.20	0.00
462	Communicate and Report	0360	WRIST-FINGER SPEED	06-Route (Outside the Section)	0.00		1.20	0.00
463	Communicate and Report	0360	WRIST-FINGER SPEED	07-Send Message	0.00		1.20	0.00
464	Communicate and Report	0360	WRIST-FINGER SPEED	08-Verbal Order	0.00		1.20	0.00
465	Communicate and Report	0360	WRIST-FINGER SPEED	09-Roll Up Reports	0.00		1.20	0.00
466	Communicate and Report	0360	WRIST-FINGER SPEED	10-Call to Conference	0.00		1.20	0.00
467	Communicate and Report	0360	WRIST-FINGER SPEED	26-Receive Digital Message	1.00		1.20	1.20
468	Communicate and Report	0360	WRIST-FINGER SPEED	27-Input data Into Computer	1.00		1.20	1.20
469	Communicate and Report	0360	WRIST-FINGER SPEED	28-Send Digital Information	1.00		1.20	1.20
470	Communicate and Report	0370	FINGER DEXTERITY	01-Receive and Record/Analog	1.00		1.20	1.20
471	Communicate and Report	0370	FINGER DEXTERITY	02-Pass Information	1.00		1.20	1.20
472	Communicate and Report	0370	FINGER DEXTERITY	03-Listen-Receive Information	0.00		1.20	0.00
473	Communicate and Report	0370	FINGER DEXTERITY	04-Secondary Monitor	1.00		1.20	1.20
474	Communicate and Report	0370	FINGER DEXTERITY	05-Log Message	1.00		1.20	1.20
475	Communicate and Report	0370	FINGER DEXTERITY	06-Route (Outside the Section)	0.00		1.20	0.00
476	Communicate and Report	0370	FINGER DEXTERITY	07-Send Message	1.00		1.20	1.20
477	Communicate and Report	0370	FINGER DEXTERITY	08-Verbal Order	0.00		1.20	0.00
478	Communicate and Report	0370	FINGER DEXTERITY	09-Roll Up Reports	1.00		1.20	1.20

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
479	Communicate and Report	0370	FINGER DEXTERITY	10-Call to Conference	0.00		1.20	0.00
480	Communicate and Report	0370	FINGER DEXTERITY	26-Receive Digital Message	0.00		1.20	0.00
481	Communicate and Report	0370	FINGER DEXTERITY	27-Input data Into Computer	1.00		1.20	1.20
482	Communicate and Report	0370	FINGER DEXTERITY	28-Send Digital Information	1.00		1.20	1.20
483	Communicate and Report	0380	MANUAL DEXTERITY	01-Receive and Record/Analog	0.00		1.20	0.00
484	Communicate and Report	0380	MANUAL DEXTERITY	02-Pass Information	0.00		1.20	0.00
485	Communicate and Report	0380	MANUAL DEXTERITY	03-Listen-Receive Information	0.00		1.20	0.00
486	Communicate and Report	0380	MANUAL DEXTERITY	04-Secondary Monitor	0.00		1.20	0.00
487	Communicate and Report	0380	MANUAL DEXTERITY	05-Log Message	0.00		1.20	0.00
488	Communicate and Report	0380	MANUAL DEXTERITY	06-Route (Outside the Section)	0.00		1.20	0.00
489	Communicate and Report	0380	MANUAL DEXTERITY	07-Send Message	0.00		1.20	0.00
490	Communicate and Report	0380	MANUAL DEXTERITY	08-Verbal Order	0.00		1.20	0.00
491	Communicate and Report	0380	MANUAL DEXTERITY	09-Roll Up Reports	0.00		1.20	0.00
492	Communicate and Report	0380	MANUAL DEXTERITY	10-Call to Conference	0.00		1.20	0.00
493	Communicate and Report	0380	MANUAL DEXTERITY	26-Receive Digital Message	1.13		1.20	1.36
494	Communicate and Report	0380	MANUAL DEXTERITY	27-Input data Into Computer	1.13		1.20	1.36
495	Communicate and Report	0380	MANUAL DEXTERITY	28-Send Digital Information	1.13		1.20	1.36
496	Communicate and Report	0390	ARM-HAND STEADINESS	01-Receive and Record/Analog	0.00		1.20	0.00
497	Communicate and Report	0390	ARM-HAND STEADINESS	02-Pass Information	0.00		1.20	0.00
498	Communicate and Report	0390	ARM-HAND STEADINESS	03-Listen-Receive Information	0.00		1.20	0.00
499	Communicate and Report	0390	ARM-HAND STEADINESS	04-Secondary Monitor	0.00		1.20	0.00
500	Communicate and Report	0390	ARM-HAND STEADINESS	05-Log Message	0.00		1.20	0.00
501	Communicate and Report	0390	ARM-HAND STEADINESS	06-Route (Outside the Section)	0.00		1.20	0.00
502	Communicate and Report	0390	ARM-HAND STEADINESS	07-Send Message	0.00		1.20	0.00
503	Communicate and Report	0390	ARM-HAND STEADINESS	08-Verbal Order	0.00		1.20	0.00
504	Communicate and Report	0390	ARM-HAND STEADINESS	09-Roll Up Reports	0.00		1.20	0.00
505	Communicate and Report	0390	ARM-HAND STEADINESS	10-Call to Conference	0.00		1.20	0.00
506	Communicate and Report	0390	ARM-HAND STEADINESS	26-Receive Digital Message	0.00		1.20	0.00
507	Communicate and Report	0390	ARM-HAND STEADINESS	27-Input data Into Computer	0.00		1.20	0.00
508	Communicate and Report	0390	ARM-HAND STEADINESS	28-Send Digital Information	0.00		1.20	0.00
509	Communicate and Report	0400	MULTI-LIMB COORDINATI	01-Receive and Record/Analog	0.00		1.20	0.00
510	Communicate and Report	0400	MULTI-LIMB COORDINATI	02-Pass Information	0.00		1.20	0.00
511	Communicate and Report	0400	MULTI-LIMB COORDINATI	03-Listen-Receive Information	0.00		1.20	0.00
512	Communicate and Report	0400	MULTI-LIMB COORDINATI	04-Secondary Monitor	0.00		1.20	0.00
513	Communicate and Report	0400	MULTI-LIMB COORDINATI	05-Log Message	0.00		1.20	0.00
514	Communicate and Report	0400	MULTI-LIMB COORDINATI	06-Route (Outside the Section)	0.00		1.20	0.00
515	Communicate and Report	0400	MULTI-LIMB COORDINATI	07-Send Message	0.00		1.20	0.00
516	Communicate and Report	0400	MULTI-LIMB COORDINATI	08-Verbal Order	0.00		1.20	0.00
517	Communicate and Report	0400	MULTI-LIMB COORDINATI	09-Roll Up Reports	0.00		1.20	0.00
518	Communicate and Report	0400	MULTI-LIMB COORDINATI	10-Call to Conference	0.00		1.20	0.00
519	Communicate and Report	0400	MULTI-LIMB COORDINATI	26-Receive Digital Message	0.00		1.20	0.00
520	Communicate and Report	0400	MULTI-LIMB COORDINATI	27-Input data Into Computer	0.00		1.20	0.00
521	Communicate and Report	0400	MULTI-LIMB COORDINATI	28-Send Digital Information	0.00		1.20	0.00
522	Communicate and Report	0410	EXTENT FLEXIBILITY	01-Receive and Record/Analog	0.00		1.20	0.00
523	Communicate and Report	0410	EXTENT FLEXIBILITY	02-Pass Information	0.00		1.20	0.00
524	Communicate and Report	0410	EXTENT FLEXIBILITY	03-Listen-Receive Information	0.00		1.20	0.00
525	Communicate and Report	0410	EXTENT FLEXIBILITY	04-Secondary Monitor	0.00		1.20	0.00
526	Communicate and Report	0410	EXTENT FLEXIBILITY	05-Log Message	0.00		1.20	0.00
527	Communicate and Report	0410	EXTENT FLEXIBILITY	06-Route (Outside the Section)	0.00		1.20	0.00
528	Communicate and Report	0410	EXTENT FLEXIBILITY	07-Send Message	0.00		1.20	0.00
529	Communicate and Report	0410	EXTENT FLEXIBILITY	08-Verbal Order	0.00		1.20	0.00
530	Communicate and Report	0410	EXTENT FLEXIBILITY	09-Roll Up Reports	0.00		1.20	0.00
531	Communicate and Report	0410	EXTENT FLEXIBILITY	10-Call to Conference	0.00		1.20	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
532	Communicate and Report	0410	EXTENT FLEXIBILITY	26-Receive Digital Message	0.00		1.20	0.00
533	Communicate and Report	0410	EXTENT FLEXIBILITY	27-Input data Into Computer	0.00		1.20	0.00
534	Communicate and Report	0410	EXTENT FLEXIBILITY	28-Send Digital Information	0.00		1.20	0.00
535	Communicate and Report	0420	DYNAMIC FLEXIBILITY	01-Receive and Record/Analog	0.00		1.20	0.00
536	Communicate and Report	0420	DYNAMIC FLEXIBILITY	02-Pass Information	0.00		1.20	0.00
537	Communicate and Report	0420	DYNAMIC FLEXIBILITY	03-Listen-Receive Information	0.00		1.20	0.00
538	Communicate and Report	0420	DYNAMIC FLEXIBILITY	04-Secondary Monitor	0.00		1.20	0.00
539	Communicate and Report	0420	DYNAMIC FLEXIBILITY	05-Log Message	0.00		1.20	0.00
540	Communicate and Report	0420	DYNAMIC FLEXIBILITY	06-Route (Outside the Section)	0.00		1.20	0.00
541	Communicate and Report	0420	DYNAMIC FLEXIBILITY	07-Send Message	0.00		1.20	0.00
542	Communicate and Report	0420	DYNAMIC FLEXIBILITY	08-Verbal Order	0.00		1.20	0.00
543	Communicate and Report	0420	DYNAMIC FLEXIBILITY	09-Roll Up Reports	0.00		1.20	0.00
544	Communicate and Report	0420	DYNAMIC FLEXIBILITY	10-Call to Conference	0.00		1.20	0.00
545	Communicate and Report	0420	DYNAMIC FLEXIBILITY	26-Receive Digital Message	0.00		1.20	0.00
546	Communicate and Report	0420	DYNAMIC FLEXIBILITY	27-Input data Into Computer	0.00		1.20	0.00
547	Communicate and Report	0420	DYNAMIC FLEXIBILITY	28-Send Digital Information	0.00		1.20	0.00
548	Communicate and Report	0430	SPEED OF LIMB MOVEMEI	01-Receive and Record/Analog	0.00		1.20	0.00
549	Communicate and Report	0430	SPEED OF LIMB MOVEMEI	02-Pass Information	0.00		1.20	0.00
550	Communicate and Report	0430	SPEED OF LIMB MOVEMEI	03-Listen-Receive Information	0.00		1.20	0.00
551	Communicate and Report	0430	SPEED OF LIMB MOVEMEI	04-Secondary Monitor	0.00		1.20	0.00
552	Communicate and Report	0430	SPEED OF LIMB MOVEMEI	05-Log Message	0.00		1.20	0.00
553	Communicate and Report	0430	SPEED OF LIMB MOVEMEI	06-Route (Outside the Section)	0.00		1.20	0.00
554	Communicate and Report	0430	SPEED OF LIMB MOVEMEI	07-Send Message	0.00		1.20	0.00
555	Communicate and Report	0430	SPEED OF LIMB MOVEMEI	08-Verbal Order	0.00		1.20	0.00
556	Communicate and Report	0430	SPEED OF LIMB MOVEMEI	09-Roll Up Reports	0.00		1.20	0.00
557	Communicate and Report	0430	SPEED OF LIMB MOVEMEI	10-Call to Conference	0.00		1.20	0.00
558	Communicate and Report	0430	SPEED OF LIMB MOVEMEI	26-Receive Digital Message	0.00		1.20	0.00
559	Communicate and Report	0430	SPEED OF LIMB MOVEMEI	27-Input data Into Computer	0.00		1.20	0.00
560	Communicate and Report	0430	SPEED OF LIMB MOVEMEI	28-Send Digital Information	0.00		1.20	0.00
561	Communicate and Report	0440	GROSS BODY EQUILIBRIU	01-Receive and Record/Analog	0.00		1.20	0.00
562	Communicate and Report	0440	GROSS BODY EQUILIBRIU	02-Pass Information	0.00		1.20	0.00
563	Communicate and Report	0440	GROSS BODY EQUILIBRIU	03-Listen-Receive Information	0.00		1.20	0.00
564	Communicate and Report	0440	GROSS BODY EQUILIBRIU	04-Secondary Monitor	0.00		1.20	0.00
565	Communicate and Report	0440	GROSS BODY EQUILIBRIU	05-Log Message	0.00		1.20	0.00
566	Communicate and Report	0440	GROSS BODY EQUILIBRIU	06-Route (Outside the Section)	0.00		1.20	0.00
567	Communicate and Report	0440	GROSS BODY EQUILIBRIU	07-Send Message	0.00		1.20	0.00
568	Communicate and Report	0440	GROSS BODY EQUILIBRIU	08-Verbal Order	0.00		1.20	0.00
569	Communicate and Report	0440	GROSS BODY EQUILIBRIU	09-Roll Up Reports	0.00		1.20	0.00
570	Communicate and Report	0440	GROSS BODY EQUILIBRIU	10-Call to Conference	0.00		1.20	0.00
571	Communicate and Report	0440	GROSS BODY EQUILIBRIU	26-Receive Digital Message	0.00		1.20	0.00
572	Communicate and Report	0440	GROSS BODY EQUILIBRIU	27-Input data Into Computer	0.00		1.20	0.00
573	Communicate and Report	0440	GROSS BODY EQUILIBRIU	28-Send Digital Information	0.00		1.20	0.00
574	Communicate and Report	0450	GROSS BODY COORDINA	01-Receive and Record/Analog	0.00		1.20	0.00
575	Communicate and Report	0450	GROSS BODY COORDINA	02-Pass Information	0.00		1.20	0.00
576	Communicate and Report	0450	GROSS BODY COORDINA	03-Listen-Receive Information	0.00		1.20	0.00
577	Communicate and Report	0450	GROSS BODY COORDINA	04-Secondary Monitor	0.00		1.20	0.00
578	Communicate and Report	0450	GROSS BODY COORDINA	05-Log Message	0.00		1.20	0.00
579	Communicate and Report	0450	GROSS BODY COORDINA	06-Route (Outside the Section)	1.00		1.20	1.20
580	Communicate and Report	0450	GROSS BODY COORDINA	07-Send Message	0.00		1.20	0.00
581	Communicate and Report	0450	GROSS BODY COORDINA	08-Verbal Order	0.00		1.20	0.00
582	Communicate and Report	0450	GROSS BODY COORDINA	09-Roll Up Reports	0.00		1.20	0.00
583	Communicate and Report	0450	GROSS BODY COORDINA	10-Call to Conference	0.00		1.20	0.00
584	Communicate and Report	0450	GROSS BODY COORDINA	26-Receive Digital Message	0.00		1.20	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
585	Communicate and Report	0450	GROSS BODY COORDINA	27-Input data Into Computer	0.00		1.20	0.00
586	Communicate and Report	0450	GROSS BODY COORDINA	28-Send Digital Information	0.00		1.20	0.00
587	Communicate and Report	0460	STATIC STRENGTH	01-Receive and Record/Analog	0.00		1.20	0.00
588	Communicate and Report	0460	STATIC STRENGTH	02-Pass Information	0.00		1.20	0.00
589	Communicate and Report	0460	STATIC STRENGTH	03-Listen-Receive Information	0.00		1.20	0.00
590	Communicate and Report	0460	STATIC STRENGTH	04-Secondary Monitor	0.00		1.20	0.00
591	Communicate and Report	0460	STATIC STRENGTH	05-Log Message	0.00		1.20	0.00
592	Communicate and Report	0460	STATIC STRENGTH	06-Route (Outside the Section)	0.00		1.20	0.00
593	Communicate and Report	0460	STATIC STRENGTH	07-Send Message	0.00		1.20	0.00
594	Communicate and Report	0460	STATIC STRENGTH	08-Verbal Order	0.00		1.20	0.00
595	Communicate and Report	0460	STATIC STRENGTH	09-Roll Up Reports	0.00		1.20	0.00
596	Communicate and Report	0460	STATIC STRENGTH	10-Call to Conference	0.00		1.20	0.00
597	Communicate and Report	0460	STATIC STRENGTH	26-Receive Digital Message	0.00		1.20	0.00
598	Communicate and Report	0460	STATIC STRENGTH	27-Input data Into Computer	0.00		1.20	0.00
599	Communicate and Report	0460	STATIC STRENGTH	28-Send Digital Information	0.00		1.20	0.00
600	Communicate and Report	0470	EXPLOSIVE STRENGTH	01-Receive and Record/Analog	0.00		1.20	0.00
601	Communicate and Report	0470	EXPLOSIVE STRENGTH	02-Pass Information	0.00		1.20	0.00
602	Communicate and Report	0470	EXPLOSIVE STRENGTH	03-Listen-Receive Information	0.00		1.20	0.00
603	Communicate and Report	0470	EXPLOSIVE STRENGTH	04-Secondary Monitor	0.00		1.20	0.00
604	Communicate and Report	0470	EXPLOSIVE STRENGTH	05-Log Message	0.00		1.20	0.00
605	Communicate and Report	0470	EXPLOSIVE STRENGTH	06-Route (Outside the Section)	0.00		1.20	0.00
606	Communicate and Report	0470	EXPLOSIVE STRENGTH	07-Send Message	0.00		1.20	0.00
607	Communicate and Report	0470	EXPLOSIVE STRENGTH	08-Verbal Order	0.00		1.20	0.00
608	Communicate and Report	0470	EXPLOSIVE STRENGTH	09-Roll Up Reports	0.00		1.20	0.00
609	Communicate and Report	0470	EXPLOSIVE STRENGTH	10-Call to Conference	0.00		1.20	0.00
610	Communicate and Report	0470	EXPLOSIVE STRENGTH	26-Receive Digital Message	0.00		1.20	0.00
611	Communicate and Report	0470	EXPLOSIVE STRENGTH	27-Input data Into Computer	0.00		1.20	0.00
612	Communicate and Report	0470	EXPLOSIVE STRENGTH	28-Send Digital Information	0.00		1.20	0.00
613	Communicate and Report	0480	DYNAMIC STRENGTH	01-Receive and Record/Analog	0.00		1.20	0.00
614	Communicate and Report	0480	DYNAMIC STRENGTH	02-Pass Information	0.00		1.20	0.00
615	Communicate and Report	0480	DYNAMIC STRENGTH	03-Listen-Receive Information	0.00		1.20	0.00
616	Communicate and Report	0480	DYNAMIC STRENGTH	04-Secondary Monitor	0.00		1.20	0.00
617	Communicate and Report	0480	DYNAMIC STRENGTH	05-Log Message	0.00		1.20	0.00
618	Communicate and Report	0480	DYNAMIC STRENGTH	06-Route (Outside the Section)	0.00		1.20	0.00
619	Communicate and Report	0480	DYNAMIC STRENGTH	07-Send Message	0.00		1.20	0.00
620	Communicate and Report	0480	DYNAMIC STRENGTH	08-Verbal Order	0.00		1.20	0.00
621	Communicate and Report	0480	DYNAMIC STRENGTH	09-Roll Up Reports	0.00		1.20	0.00
622	Communicate and Report	0480	DYNAMIC STRENGTH	10-Call to Conference	0.00		1.20	0.00
623	Communicate and Report	0480	DYNAMIC STRENGTH	26-Receive Digital Message	0.00		1.20	0.00
624	Communicate and Report	0480	DYNAMIC STRENGTH	27-Input data Into Computer	0.00		1.20	0.00
625	Communicate and Report	0480	DYNAMIC STRENGTH	28-Send Digital Information	0.00		1.20	0.00
626	Communicate and Report	0490	TRUNK STRENGTH	01-Receive and Record/Analog	0.00		1.20	0.00
627	Communicate and Report	0490	TRUNK STRENGTH	02-Pass Information	0.00		1.20	0.00
628	Communicate and Report	0490	TRUNK STRENGTH	03-Listen-Receive Information	0.00		1.20	0.00
629	Communicate and Report	0490	TRUNK STRENGTH	04-Secondary Monitor	0.00		1.20	0.00
630	Communicate and Report	0490	TRUNK STRENGTH	05-Log Message	0.00		1.20	0.00
631	Communicate and Report	0490	TRUNK STRENGTH	06-Route (Outside the Section)	0.00		1.20	0.00
632	Communicate and Report	0490	TRUNK STRENGTH	07-Send Message	0.00		1.20	0.00
633	Communicate and Report	0490	TRUNK STRENGTH	08-Verbal Order	0.00		1.20	0.00
634	Communicate and Report	0490	TRUNK STRENGTH	09-Roll Up Reports	0.00		1.20	0.00
635	Communicate and Report	0490	TRUNK STRENGTH	10-Call to Conference	0.00		1.20	0.00
636	Communicate and Report	0490	TRUNK STRENGTH	26-Receive Digital Message	0.00		1.20	0.00
637	Communicate and Report	0490	TRUNK STRENGTH	27-Input data Into Computer	0.00		1.20	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
638	Communicate and Report	0490	TRUNK STRENGTH	28-Send Digital Information	0.00		1.20	0.00
639	Communicate and Report	0500	STAMINA	01-Receive and Record/Analog	0.00		1.20	0.00
640	Communicate and Report	0500	STAMINA	02-Pass Information	0.00		1.20	0.00
641	Communicate and Report	0500	STAMINA	03-Listen-Receive Information	0.00		1.20	0.00
642	Communicate and Report	0500	STAMINA	04-Secondary Monitor	0.00		1.20	0.00
643	Communicate and Report	0500	STAMINA	05-Log Message	0.00		1.20	0.00
644	Communicate and Report	0500	STAMINA	06-Route (Outside the Section)	0.00		1.20	0.00
645	Communicate and Report	0500	STAMINA	07-Send Message	0.00		1.20	0.00
646	Communicate and Report	0500	STAMINA	08-Verbal Order	0.00		1.20	0.00
647	Communicate and Report	0500	STAMINA	09-Roll Up Reports	0.00		1.20	0.00
648	Communicate and Report	0500	STAMINA	10-Call to Conference	0.00		1.20	0.00
649	Communicate and Report	0500	STAMINA	26-Receive Digital Message	0.00		1.20	0.00
650	Communicate and Report	0500	STAMINA	27-Input data Into Computer	0.00		1.20	0.00
651	Communicate and Report	0500	STAMINA	28-Send Digital Information	0.00		1.20	0.00
652	Decide and Recommend / D	0010	ORAL COMPREHENSION	11-Decide Action	0.00		0.80	0.00
653	Decide and Recommend / D	0010	ORAL COMPREHENSION	12-Decide	1.92		0.80	1.54
654	Decide and Recommend / D	0010	ORAL COMPREHENSION	13-Recommend Action	1.92		0.80	1.54
655	Decide and Recommend / D	0020	WRITTEN COMPREHENSIO	11-Decide Action	1.61		0.80	1.29
656	Decide and Recommend / D	0020	WRITTEN COMPREHENSIO	12-Decide	1.61		0.80	1.29
657	Decide and Recommend / D	0020	WRITTEN COMPREHENSIO	13-Recommend Action	1.61		0.80	1.29
658	Decide and Recommend / D	0030	ORAL EXPRESSION	11-Decide Action	0.00		0.80	0.00
659	Decide and Recommend / D	0030	ORAL EXPRESSION	12-Decide	2.34		0.80	1.87
660	Decide and Recommend / D	0030	ORAL EXPRESSION	13-Recommend Action	2.34		0.80	1.87
661	Decide and Recommend / D	0040	WRITTEN EXPRESSION	11-Decide Action	0.00		0.80	0.00
662	Decide and Recommend / D	0040	WRITTEN EXPRESSION	12-Decide	0.00		0.80	0.00
663	Decide and Recommend / D	0040	WRITTEN EXPRESSION	13-Recommend Action	0.00		0.80	0.00
664	Decide and Recommend / D	0050	MEMORIZATION	11-Decide Action	2.61		0.80	2.09
665	Decide and Recommend / D	0050	MEMORIZATION	12-Decide	2.61		0.80	2.09
666	Decide and Recommend / D	0050	MEMORIZATION	13-Recommend Action	2.61		0.80	2.09
667	Decide and Recommend / D	0060	PROBLEM SENSITIVITY	11-Decide Action	2.12		0.80	1.70
668	Decide and Recommend / D	0060	PROBLEM SENSITIVITY	12-Decide	2.12		0.80	1.70
669	Decide and Recommend / D	0060	PROBLEM SENSITIVITY	13-Recommend Action	2.12		0.80	1.70
670	Decide and Recommend / D	0070	ORIGINALITY	11-Decide Action	0.00		0.80	0.00
671	Decide and Recommend / D	0070	ORIGINALITY	12-Decide	0.00		0.80	0.00
672	Decide and Recommend / D	0070	ORIGINALITY	13-Recommend Action	0.00		0.80	0.00
673	Decide and Recommend / D	0080	FLUENCY OF IDEAS	11-Decide Action	0.00		0.80	0.00
674	Decide and Recommend / D	0080	FLUENCY OF IDEAS	12-Decide	0.00		0.80	0.00
675	Decide and Recommend / D	0080	FLUENCY OF IDEAS	13-Recommend Action	0.00		0.80	0.00
676	Decide and Recommend / D	0090	FLEXIBILITY OF CLOSURE	11-Decide Action	1.51		0.80	1.21
677	Decide and Recommend / D	0090	FLEXIBILITY OF CLOSURE	12-Decide	1.51		0.80	1.21
678	Decide and Recommend / D	0090	FLEXIBILITY OF CLOSURE	13-Recommend Action	0.00		0.80	0.00
679	Decide and Recommend / D	0100	SELECTIVE ATTENTION	11-Decide Action	1.50		0.80	1.20
680	Decide and Recommend / D	0100	SELECTIVE ATTENTION	12-Decide	1.50		0.80	1.20
681	Decide and Recommend / D	0100	SELECTIVE ATTENTION	13-Recommend Action	0.00		0.80	0.00
682	Decide and Recommend / D	0110	SPATIAL ORIENTATION	11-Decide Action	0.00		0.80	0.00
683	Decide and Recommend / D	0110	SPATIAL ORIENTATION	12-Decide	0.00		0.80	0.00
684	Decide and Recommend / D	0110	SPATIAL ORIENTATION	13-Recommend Action	0.00		0.80	0.00
685	Decide and Recommend / D	0120	VISUALIZATION	11-Decide Action	2.17		0.80	1.74
686	Decide and Recommend / D	0120	VISUALIZATION	12-Decide	2.17		0.80	1.74
687	Decide and Recommend / D	0120	VISUALIZATION	13-Recommend Action	0.00		0.80	0.00
688	Decide and Recommend / D	0130	INDUCTIVE REASONING	11-Decide Action	2.43		0.80	1.94
689	Decide and Recommend / D	0130	INDUCTIVE REASONING	12-Decide	2.43		0.80	1.94
690	Decide and Recommend / D	0130	INDUCTIVE REASONING	13-Recommend Action	0.00		0.80	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
691	Decide and Recommend / D	0140	CATEGORY FLEXIBILITY	11-Decide Action	0.00		0.80	0.00
692	Decide and Recommend / D	0140	CATEGORY FLEXIBILITY	12-Decide	0.00		0.80	0.00
693	Decide and Recommend / D	0140	CATEGORY FLEXIBILITY	13-Recommend Action	0.00		0.80	0.00
694	Decide and Recommend / D	0150	DEDUCTIVE REASONING	11-Decide Action	2.79		0.80	2.23
695	Decide and Recommend / D	0150	DEDUCTIVE REASONING	12-Decide	2.79		0.80	2.23
696	Decide and Recommend / D	0150	DEDUCTIVE REASONING	13-Recommend Action	2.79		0.80	2.23
697	Decide and Recommend / D	0160	INFORMATION ORDERING	11-Decide Action	2.85		0.80	2.28
698	Decide and Recommend / D	0160	INFORMATION ORDERING	12-Decide	2.85		0.80	2.28
699	Decide and Recommend / D	0160	INFORMATION ORDERING	13-Recommend Action	2.85		0.80	2.28
700	Decide and Recommend / D	0170	MATHEMATICAL REASONI	11-Decide Action	2.13		0.80	1.70
701	Decide and Recommend / D	0170	MATHEMATICAL REASONI	12-Decide	2.13		0.80	1.70
702	Decide and Recommend / D	0170	MATHEMATICAL REASONI	13-Recommend Action	2.13		0.80	1.70
703	Decide and Recommend / D	0180	NUMBER FACILITY	11-Decide Action	0.00		0.80	0.00
704	Decide and Recommend / D	0180	NUMBER FACILITY	12-Decide	0.00		0.80	0.00
705	Decide and Recommend / D	0180	NUMBER FACILITY	13-Recommend Action	0.00		0.80	0.00
706	Decide and Recommend / D	0190	TIME SHARING	11-Decide Action	2.00		0.80	1.60
707	Decide and Recommend / D	0190	TIME SHARING	12-Decide	2.00		0.80	1.60
708	Decide and Recommend / D	0190	TIME SHARING	13-Recommend Action	2.00		0.80	1.60
709	Decide and Recommend / D	0200	SPEED OF CLOSURE	11-Decide Action	2.19		0.80	1.75
710	Decide and Recommend / D	0200	SPEED OF CLOSURE	12-Decide	2.19		0.80	1.75
711	Decide and Recommend / D	0200	SPEED OF CLOSURE	13-Recommend Action	2.19		0.80	1.75
712	Decide and Recommend / D	0210	PERCEPTUAL SPEED AND	11-Decide Action	2.35		0.80	1.88
713	Decide and Recommend / D	0210	PERCEPTUAL SPEED AND	12-Decide	2.35		0.80	1.88
714	Decide and Recommend / D	0210	PERCEPTUAL SPEED AND	13-Recommend Action	0.00		0.80	0.00
715	Decide and Recommend / D	0220	REACTION TIME	11-Decide Action	0.00		0.80	0.00
716	Decide and Recommend / D	0220	REACTION TIME	12-Decide	0.00		0.80	0.00
717	Decide and Recommend / D	0220	REACTION TIME	13-Recommend Action	0.00		0.80	0.00
718	Decide and Recommend / D	0230	CHOICE REACTION TIME	11-Decide Action	0.00		0.80	0.00
719	Decide and Recommend / D	0230	CHOICE REACTION TIME	12-Decide	0.00		0.80	0.00
720	Decide and Recommend / D	0230	CHOICE REACTION TIME	13-Recommend Action	0.00		0.80	0.00
721	Decide and Recommend / D	0240	NEAR VISION	11-Decide Action	0.00		0.80	0.00
722	Decide and Recommend / D	0240	NEAR VISION	12-Decide	0.00		0.80	0.00
723	Decide and Recommend / D	0240	NEAR VISION	13-Recommend Action	0.00		0.80	0.00
724	Decide and Recommend / D	0250	FAR VISION	11-Decide Action	0.00		0.80	0.00
725	Decide and Recommend / D	0250	FAR VISION	12-Decide	0.00		0.80	0.00
726	Decide and Recommend / D	0250	FAR VISION	13-Recommend Action	0.00		0.80	0.00
727	Decide and Recommend / D	0260	NIGHT VISION	11-Decide Action	0.00		0.80	0.00
728	Decide and Recommend / D	0260	NIGHT VISION	12-Decide	0.00		0.80	0.00
729	Decide and Recommend / D	0260	NIGHT VISION	13-Recommend Action	0.00		0.80	0.00
730	Decide and Recommend / D	0270	VISUAL COLOR DISCRIMIN	11-Decide Action	0.00		0.80	0.00
731	Decide and Recommend / D	0270	VISUAL COLOR DISCRIMIN	12-Decide	0.00		0.80	0.00
732	Decide and Recommend / D	0270	VISUAL COLOR DISCRIMIN	13-Recommend Action	0.00		0.80	0.00
733	Decide and Recommend / D	0280	PERIPHERAL VISION	11-Decide Action	0.00		0.80	0.00
734	Decide and Recommend / D	0280	PERIPHERAL VISION	12-Decide	0.00		0.80	0.00
735	Decide and Recommend / D	0280	PERIPHERAL VISION	13-Recommend Action	0.00		0.80	0.00
736	Decide and Recommend / D	0290	DEPTH PERCEPTION	11-Decide Action	0.00		0.80	0.00
737	Decide and Recommend / D	0290	DEPTH PERCEPTION	12-Decide	0.00		0.80	0.00
738	Decide and Recommend / D	0290	DEPTH PERCEPTION	13-Recommend Action	0.00		0.80	0.00
739	Decide and Recommend / D	0300	GLARE SENSITIVITY	11-Decide Action	0.00		0.80	0.00
740	Decide and Recommend / D	0300	GLARE SENSITIVITY	12-Decide	0.00		0.80	0.00
741	Decide and Recommend / D	0300	GLARE SENSITIVITY	13-Recommend Action	0.00		0.80	0.00
742	Decide and Recommend / D	0310	GENERAL HEARING	11-Decide Action	0.00		0.80	0.00
743	Decide and Recommend / D	0310	GENERAL HEARING	12-Decide	0.00		0.80	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
744	Decide and Recommend / D	0310	GENERAL HEARING	13-Recommend Action	0.00		0.80	0.00
745	Decide and Recommend / D	0320	AUDITORY ATTENTION	11-Decide Action	0.00		0.80	0.00
746	Decide and Recommend / D	0320	AUDITORY ATTENTION	12-Decide	2.17		0.80	1.74
747	Decide and Recommend / D	0320	AUDITORY ATTENTION	13-Recommend Action	2.17		0.80	1.74
748	Decide and Recommend / D	0330	SOUND LOCALIZATION	11-Decide Action	0.00		0.80	0.00
749	Decide and Recommend / D	0330	SOUND LOCALIZATION	12-Decide	0.00		0.80	0.00
750	Decide and Recommend / D	0330	SOUND LOCALIZATION	13-Recommend Action	0.00		0.80	0.00
751	Decide and Recommend / D	0340	CONTROL PRECISION	11-Decide Action	0.00		0.80	0.00
752	Decide and Recommend / D	0340	CONTROL PRECISION	12-Decide	0.00		0.80	0.00
753	Decide and Recommend / D	0340	CONTROL PRECISION	13-Recommend Action	0.00		0.80	0.00
754	Decide and Recommend / D	0350	RATE CONTROL	11-Decide Action	0.00		0.80	0.00
755	Decide and Recommend / D	0350	RATE CONTROL	12-Decide	0.00		0.80	0.00
756	Decide and Recommend / D	0350	RATE CONTROL	13-Recommend Action	0.00		0.80	0.00
757	Decide and Recommend / D	0360	WRIST-FINGER SPEED	11-Decide Action	0.00		0.80	0.00
758	Decide and Recommend / D	0360	WRIST-FINGER SPEED	12-Decide	0.00		0.80	0.00
759	Decide and Recommend / D	0360	WRIST-FINGER SPEED	13-Recommend Action	0.00		0.80	0.00
760	Decide and Recommend / D	0370	FINGER DEXTERITY	11-Decide Action	0.00		0.80	0.00
761	Decide and Recommend / D	0370	FINGER DEXTERITY	12-Decide	0.00		0.80	0.00
762	Decide and Recommend / D	0370	FINGER DEXTERITY	13-Recommend Action	0.00		0.80	0.00
763	Decide and Recommend / D	0380	MANUAL DEXTERITY	11-Decide Action	0.00		0.80	0.00
764	Decide and Recommend / D	0380	MANUAL DEXTERITY	12-Decide	0.00		0.80	0.00
765	Decide and Recommend / D	0380	MANUAL DEXTERITY	13-Recommend Action	0.00		0.80	0.00
766	Decide and Recommend / D	0390	ARM-HAND STEADINESS	11-Decide Action	0.00		0.80	0.00
767	Decide and Recommend / D	0390	ARM-HAND STEADINESS	12-Decide	0.00		0.80	0.00
768	Decide and Recommend / D	0390	ARM-HAND STEADINESS	13-Recommend Action	0.00		0.80	0.00
769	Decide and Recommend / D	0400	MULTI-LIMB COORDINATI	11-Decide Action	0.00		0.80	0.00
770	Decide and Recommend / D	0400	MULTI-LIMB COORDINATI	12-Decide	0.00		0.80	0.00
771	Decide and Recommend / D	0400	MULTI-LIMB COORDINATI	13-Recommend Action	0.00		0.80	0.00
772	Decide and Recommend / D	0410	EXTENT FLEXIBILITY	11-Decide Action	0.00		0.80	0.00
773	Decide and Recommend / D	0410	EXTENT FLEXIBILITY	12-Decide	0.00		0.80	0.00
774	Decide and Recommend / D	0410	EXTENT FLEXIBILITY	13-Recommend Action	0.00		0.80	0.00
775	Decide and Recommend / D	0420	DYNAMIC FLEXIBILITY	11-Decide Action	0.00		0.80	0.00
776	Decide and Recommend / D	0420	DYNAMIC FLEXIBILITY	12-Decide	0.00		0.80	0.00
777	Decide and Recommend / D	0420	DYNAMIC FLEXIBILITY	13-Recommend Action	0.00		0.80	0.00
778	Decide and Recommend / D	0430	SPEED OF LIMB MOVEMEI	11-Decide Action	0.00		0.80	0.00
779	Decide and Recommend / D	0430	SPEED OF LIMB MOVEMEI	12-Decide	0.00		0.80	0.00
780	Decide and Recommend / D	0430	SPEED OF LIMB MOVEMEI	13-Recommend Action	0.00		0.80	0.00
781	Decide and Recommend / D	0440	GROSS BODY EQUILIBRIU	11-Decide Action	0.00		0.80	0.00
782	Decide and Recommend / D	0440	GROSS BODY EQUILIBRIU	12-Decide	0.00		0.80	0.00
783	Decide and Recommend / D	0440	GROSS BODY EQUILIBRIU	13-Recommend Action	0.00		0.80	0.00
784	Decide and Recommend / D	0450	GROSS BODY COORDINA	11-Decide Action	0.00		0.80	0.00
785	Decide and Recommend / D	0450	GROSS BODY COORDINA	12-Decide	0.00		0.80	0.00
786	Decide and Recommend / D	0450	GROSS BODY COORDINA	13-Recommend Action	0.00		0.80	0.00
787	Decide and Recommend / D	0460	STATIC STRENGTH	11-Decide Action	0.00		0.80	0.00
788	Decide and Recommend / D	0460	STATIC STRENGTH	12-Decide	0.00		0.80	0.00
789	Decide and Recommend / D	0460	STATIC STRENGTH	13-Recommend Action	0.00		0.80	0.00
790	Decide and Recommend / D	0470	EXPLOSIVE STRENGTH	11-Decide Action	0.00		0.80	0.00
791	Decide and Recommend / D	0470	EXPLOSIVE STRENGTH	12-Decide	0.00		0.80	0.00
792	Decide and Recommend / D	0470	EXPLOSIVE STRENGTH	13-Recommend Action	0.00		0.80	0.00
793	Decide and Recommend / D	0480	DYNAMIC STRENGTH	11-Decide Action	0.00		0.80	0.00
794	Decide and Recommend / D	0480	DYNAMIC STRENGTH	12-Decide	0.00		0.80	0.00
795	Decide and Recommend / D	0480	DYNAMIC STRENGTH	13-Recommend Action	0.00		0.80	0.00
796	Decide and Recommend / D	0490	TRUNK STRENGTH	11-Decide Action	0.00		0.80	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
797	Decide and Recommend / D	0490	TRUNK STRENGTH	12-Decide	0.00		0.80	0.00
798	Decide and Recommend / D	0490	TRUNK STRENGTH	13-Recommend Action	0.00		0.80	0.00
799	Decide and Recommend / D	0500	STAMINA	11-Decide Action	0.00		0.80	0.00
800	Decide and Recommend / D	0500	STAMINA	12-Decide	0.00		0.80	0.00
801	Decide and Recommend / D	0500	STAMINA	13-Recommend Action	0.00		0.80	0.00
802	Evaluate and Estimate Impa	0010	ORAL COMPREHENSION	14-Estimate Impact	0.00		0.80	0.00
803	Evaluate and Estimate Impa	0010	ORAL COMPREHENSION	15-Data Gathering/ Analog	2.07		0.80	1.66
804	Evaluate and Estimate Impa	0010	ORAL COMPREHENSION	16-Find Options	2.07		0.80	1.66
805	Evaluate and Estimate Impa	0010	ORAL COMPREHENSION	17-Compare Alternatives	2.07		0.80	1.66
806	Evaluate and Estimate Impa	0010	ORAL COMPREHENSION	18-Discuss	2.07		0.80	1.66
807	Evaluate and Estimate Impa	0010	ORAL COMPREHENSION	29-Data Gathering/ Digital	2.07		0.80	1.66
808	Evaluate and Estimate Impa	0020	WRITTEN COMPREHENSI	14-Estimate Impact	1.59		0.80	1.27
809	Evaluate and Estimate Impa	0020	WRITTEN COMPREHENSI	15-Data Gathering/ Analog	1.59		0.80	1.27
810	Evaluate and Estimate Impa	0020	WRITTEN COMPREHENSI	16-Find Options	1.59		0.80	1.27
811	Evaluate and Estimate Impa	0020	WRITTEN COMPREHENSI	17-Compare Alternatives	1.59		0.80	1.27
812	Evaluate and Estimate Impa	0020	WRITTEN COMPREHENSI	18-Discuss	0.00		0.80	0.00
813	Evaluate and Estimate Impa	0020	WRITTEN COMPREHENSI	29-Data Gathering/ Digital	1.59		0.80	1.27
814	Evaluate and Estimate Impa	0030	ORAL EXPRESSION	14-Estimate Impact	0.00		0.80	0.00
815	Evaluate and Estimate Impa	0030	ORAL EXPRESSION	15-Data Gathering/ Analog	2.41		0.80	1.93
816	Evaluate and Estimate Impa	0030	ORAL EXPRESSION	16-Find Options	2.41		0.80	1.93
817	Evaluate and Estimate Impa	0030	ORAL EXPRESSION	17-Compare Alternatives	2.41		0.80	1.93
818	Evaluate and Estimate Impa	0030	ORAL EXPRESSION	18-Discuss	2.41		0.80	1.93
819	Evaluate and Estimate Impa	0030	ORAL EXPRESSION	29-Data Gathering/ Digital	2.41		0.80	1.93
820	Evaluate and Estimate Impa	0040	WRITTEN EXPRESSION	14-Estimate Impact	0.00		0.80	0.00
821	Evaluate and Estimate Impa	0040	WRITTEN EXPRESSION	15-Data Gathering/ Analog	1.80		0.80	1.44
822	Evaluate and Estimate Impa	0040	WRITTEN EXPRESSION	16-Find Options	0.00		0.80	0.00
823	Evaluate and Estimate Impa	0040	WRITTEN EXPRESSION	17-Compare Alternatives	0.00		0.80	0.00
824	Evaluate and Estimate Impa	0040	WRITTEN EXPRESSION	18-Discuss	0.00		0.80	0.00
825	Evaluate and Estimate Impa	0040	WRITTEN EXPRESSION	29-Data Gathering/ Digital	0.00		0.80	0.00
826	Evaluate and Estimate Impa	0050	MEMORIZATION	14-Estimate Impact	2.29		0.80	1.83
827	Evaluate and Estimate Impa	0050	MEMORIZATION	15-Data Gathering/ Analog	2.29		0.80	1.83
828	Evaluate and Estimate Impa	0050	MEMORIZATION	16-Find Options	2.29		0.80	1.83
829	Evaluate and Estimate Impa	0050	MEMORIZATION	17-Compare Alternatives	2.29		0.80	1.83
830	Evaluate and Estimate Impa	0050	MEMORIZATION	18-Discuss	2.29		0.80	1.83
831	Evaluate and Estimate Impa	0050	MEMORIZATION	29-Data Gathering/ Digital	2.29		0.80	1.83
832	Evaluate and Estimate Impa	0060	PROBLEM SENSITIVITY	14-Estimate Impact	2.20		0.80	1.76
833	Evaluate and Estimate Impa	0060	PROBLEM SENSITIVITY	15-Data Gathering/ Analog	0.00		0.80	0.00
834	Evaluate and Estimate Impa	0060	PROBLEM SENSITIVITY	16-Find Options	2.20		0.80	1.76
835	Evaluate and Estimate Impa	0060	PROBLEM SENSITIVITY	17-Compare Alternatives	2.20		0.80	1.76
836	Evaluate and Estimate Impa	0060	PROBLEM SENSITIVITY	18-Discuss	0.00		0.80	0.00
837	Evaluate and Estimate Impa	0060	PROBLEM SENSITIVITY	29-Data Gathering/ Digital	2.20		0.80	1.76
838	Evaluate and Estimate Impa	0070	ORIGINALITY	14-Estimate Impact	0.00		0.80	0.00
839	Evaluate and Estimate Impa	0070	ORIGINALITY	15-Data Gathering/ Analog	0.00		0.80	0.00
840	Evaluate and Estimate Impa	0070	ORIGINALITY	16-Find Options	0.00		0.80	0.00
841	Evaluate and Estimate Impa	0070	ORIGINALITY	17-Compare Alternatives	0.00		0.80	0.00
842	Evaluate and Estimate Impa	0070	ORIGINALITY	18-Discuss	0.00		0.80	0.00
843	Evaluate and Estimate Impa	0070	ORIGINALITY	29-Data Gathering/ Digital	0.00		0.80	0.00
844	Evaluate and Estimate Impa	0080	FLUENCY OF IDEAS	14-Estimate Impact	2.61		0.80	2.09
845	Evaluate and Estimate Impa	0080	FLUENCY OF IDEAS	15-Data Gathering/ Analog	2.61		0.80	2.09
846	Evaluate and Estimate Impa	0080	FLUENCY OF IDEAS	16-Find Options	2.61		0.80	2.09
847	Evaluate and Estimate Impa	0080	FLUENCY OF IDEAS	17-Compare Alternatives	2.61		0.80	2.09
848	Evaluate and Estimate Impa	0080	FLUENCY OF IDEAS	18-Discuss	0.00		0.80	0.00
849	Evaluate and Estimate Impa	0080	FLUENCY OF IDEAS	29-Data Gathering/ Digital	2.61		0.80	2.09

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
850	Evaluate and Estimate Impa	0090	FLEXIBILITY OF CLOSURE	14-Estimate Impact	1.56		0.80	1.25
851	Evaluate and Estimate Impa	0090	FLEXIBILITY OF CLOSURE	15-Data Gathering/ Analog	0.00		0.80	0.00
852	Evaluate and Estimate Impa	0090	FLEXIBILITY OF CLOSURE	16-Find Options	1.56		0.80	1.25
853	Evaluate and Estimate Impa	0090	FLEXIBILITY OF CLOSURE	17-Compare Alternatives	1.56		0.80	1.25
854	Evaluate and Estimate Impa	0090	FLEXIBILITY OF CLOSURE	18-Discuss	0.00		0.80	0.00
855	Evaluate and Estimate Impa	0090	FLEXIBILITY OF CLOSURE	29-Data Gathering/ Digital	1.56		0.80	1.25
856	Evaluate and Estimate Impa	0100	SELECTIVE ATTENTION	14-Estimate Impact	1.50		0.80	1.20
857	Evaluate and Estimate Impa	0100	SELECTIVE ATTENTION	15-Data Gathering/ Analog	1.50		0.80	1.20
858	Evaluate and Estimate Impa	0100	SELECTIVE ATTENTION	16-Find Options	1.50		0.80	1.20
859	Evaluate and Estimate Impa	0100	SELECTIVE ATTENTION	17-Compare Alternatives	1.50		0.80	1.20
860	Evaluate and Estimate Impa	0100	SELECTIVE ATTENTION	18-Discuss	1.50		0.80	1.20
861	Evaluate and Estimate Impa	0100	SELECTIVE ATTENTION	29-Data Gathering/ Digital	1.50		0.80	1.20
862	Evaluate and Estimate Impa	0110	SPATIAL ORIENTATION	14-Estimate Impact	2.40		0.80	1.92
863	Evaluate and Estimate Impa	0110	SPATIAL ORIENTATION	15-Data Gathering/ Analog	0.00		0.80	0.00
864	Evaluate and Estimate Impa	0110	SPATIAL ORIENTATION	16-Find Options	0.00		0.80	0.00
865	Evaluate and Estimate Impa	0110	SPATIAL ORIENTATION	17-Compare Alternatives	2.40		0.80	1.92
866	Evaluate and Estimate Impa	0110	SPATIAL ORIENTATION	18-Discuss	0.00		0.80	0.00
867	Evaluate and Estimate Impa	0110	SPATIAL ORIENTATION	29-Data Gathering/ Digital	2.40		0.80	1.92
868	Evaluate and Estimate Impa	0120	VISUALIZATION	14-Estimate Impact	2.24		0.80	1.79
869	Evaluate and Estimate Impa	0120	VISUALIZATION	15-Data Gathering/ Analog	2.24		0.80	1.79
870	Evaluate and Estimate Impa	0120	VISUALIZATION	16-Find Options	2.24		0.80	1.79
871	Evaluate and Estimate Impa	0120	VISUALIZATION	17-Compare Alternatives	2.24		0.80	1.79
872	Evaluate and Estimate Impa	0120	VISUALIZATION	18-Discuss	2.24		0.80	1.79
873	Evaluate and Estimate Impa	0120	VISUALIZATION	29-Data Gathering/ Digital	2.24		0.80	1.79
874	Evaluate and Estimate Impa	0130	INDUCTIVE REASONING	14-Estimate Impact	2.36		0.80	1.89
875	Evaluate and Estimate Impa	0130	INDUCTIVE REASONING	15-Data Gathering/ Analog	2.36		0.80	1.89
876	Evaluate and Estimate Impa	0130	INDUCTIVE REASONING	16-Find Options	2.36		0.80	1.89
877	Evaluate and Estimate Impa	0130	INDUCTIVE REASONING	17-Compare Alternatives	2.36		0.80	1.89
878	Evaluate and Estimate Impa	0130	INDUCTIVE REASONING	18-Discuss	2.36		0.80	1.89
879	Evaluate and Estimate Impa	0130	INDUCTIVE REASONING	29-Data Gathering/ Digital	2.36		0.80	1.89
880	Evaluate and Estimate Impa	0140	CATEGORY FLEXIBILITY	14-Estimate Impact	2.70		0.80	2.16
881	Evaluate and Estimate Impa	0140	CATEGORY FLEXIBILITY	15-Data Gathering/ Analog	0.00		0.80	0.00
882	Evaluate and Estimate Impa	0140	CATEGORY FLEXIBILITY	16-Find Options	2.70		0.80	2.16
883	Evaluate and Estimate Impa	0140	CATEGORY FLEXIBILITY	17-Compare Alternatives	0.00		0.80	0.00
884	Evaluate and Estimate Impa	0140	CATEGORY FLEXIBILITY	18-Discuss	0.00		0.80	0.00
885	Evaluate and Estimate Impa	0140	CATEGORY FLEXIBILITY	29-Data Gathering/ Digital	2.70		0.80	2.16
886	Evaluate and Estimate Impa	0150	DEDUCTIVE REASONING	14-Estimate Impact	2.68		0.80	2.14
887	Evaluate and Estimate Impa	0150	DEDUCTIVE REASONING	15-Data Gathering/ Analog	2.68		0.80	2.14
888	Evaluate and Estimate Impa	0150	DEDUCTIVE REASONING	16-Find Options	2.68		0.80	2.14
889	Evaluate and Estimate Impa	0150	DEDUCTIVE REASONING	17-Compare Alternatives	2.68		0.80	2.14
890	Evaluate and Estimate Impa	0150	DEDUCTIVE REASONING	18-Discuss	2.68		0.80	2.14
891	Evaluate and Estimate Impa	0150	DEDUCTIVE REASONING	29-Data Gathering/ Digital	2.68		0.80	2.14
892	Evaluate and Estimate Impa	0160	INFORMATION ORDERING	14-Estimate Impact	3.05		0.80	2.44
893	Evaluate and Estimate Impa	0160	INFORMATION ORDERING	15-Data Gathering/ Analog	0.00		0.80	0.00
894	Evaluate and Estimate Impa	0160	INFORMATION ORDERING	16-Find Options	0.00		0.80	0.00
895	Evaluate and Estimate Impa	0160	INFORMATION ORDERING	17-Compare Alternatives	0.00		0.80	0.00
896	Evaluate and Estimate Impa	0160	INFORMATION ORDERING	18-Discuss	0.00		0.80	0.00
897	Evaluate and Estimate Impa	0160	INFORMATION ORDERING	29-Data Gathering/ Digital	3.05		0.80	2.44
898	Evaluate and Estimate Impa	0170	MATHEMATICAL REASONI	14-Estimate Impact	2.12		0.80	1.70
899	Evaluate and Estimate Impa	0170	MATHEMATICAL REASONI	15-Data Gathering/ Analog	2.12		0.80	1.70
900	Evaluate and Estimate Impa	0170	MATHEMATICAL REASONI	16-Find Options	0.00		0.80	0.00
901	Evaluate and Estimate Impa	0170	MATHEMATICAL REASONI	17-Compare Alternatives	2.12		0.80	1.70
902	Evaluate and Estimate Impa	0170	MATHEMATICAL REASONI	18-Discuss	0.00		0.80	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
903	Evaluate and Estimate Impa	0170	MATHEMATICAL REASONI	29-Data Gathering/ Digital	2.12		0.80	1.70
904	Evaluate and Estimate Impa	0180	NUMBER FACILITY	14-Estimate Impact	2.50		0.80	2.00
905	Evaluate and Estimate Impa	0180	NUMBER FACILITY	15-Data Gathering/ Analog	2.50		0.80	2.00
906	Evaluate and Estimate Impa	0180	NUMBER FACILITY	16-Find Options	0.00		0.80	0.00
907	Evaluate and Estimate Impa	0180	NUMBER FACILITY	17-Compare Alternatives	2.50		0.80	2.00
908	Evaluate and Estimate Impa	0180	NUMBER FACILITY	18-Discuss	0.00		0.80	0.00
909	Evaluate and Estimate Impa	0180	NUMBER FACILITY	29-Data Gathering/ Digital	2.50		0.80	2.00
910	Evaluate and Estimate Impa	0190	TIME SHARING	14-Estimate Impact	2.00		0.80	1.60
911	Evaluate and Estimate Impa	0190	TIME SHARING	15-Data Gathering/ Analog	0.00		0.80	0.00
912	Evaluate and Estimate Impa	0190	TIME SHARING	16-Find Options	2.00		0.80	1.60
913	Evaluate and Estimate Impa	0190	TIME SHARING	17-Compare Alternatives	2.00		0.80	1.60
914	Evaluate and Estimate Impa	0190	TIME SHARING	18-Discuss	2.00		0.80	1.60
915	Evaluate and Estimate Impa	0190	TIME SHARING	29-Data Gathering/ Digital	2.00		0.80	1.60
916	Evaluate and Estimate Impa	0200	SPEED OF CLOSURE	14-Estimate Impact	2.26		0.80	1.81
917	Evaluate and Estimate Impa	0200	SPEED OF CLOSURE	15-Data Gathering/ Analog	0.00		0.80	0.00
918	Evaluate and Estimate Impa	0200	SPEED OF CLOSURE	16-Find Options	2.26		0.80	1.81
919	Evaluate and Estimate Impa	0200	SPEED OF CLOSURE	17-Compare Alternatives	2.26		0.80	1.81
920	Evaluate and Estimate Impa	0200	SPEED OF CLOSURE	18-Discuss	0.00		0.80	0.00
921	Evaluate and Estimate Impa	0200	SPEED OF CLOSURE	29-Data Gathering/ Digital	2.26		0.80	1.81
922	Evaluate and Estimate Impa	0210	PERCEPTUAL SPEED AND	14-Estimate Impact	2.36		0.80	1.89
923	Evaluate and Estimate Impa	0210	PERCEPTUAL SPEED AND	15-Data Gathering/ Analog	0.00		0.80	0.00
924	Evaluate and Estimate Impa	0210	PERCEPTUAL SPEED AND	16-Find Options	0.00		0.80	0.00
925	Evaluate and Estimate Impa	0210	PERCEPTUAL SPEED AND	17-Compare Alternatives	2.36		0.80	1.89
926	Evaluate and Estimate Impa	0210	PERCEPTUAL SPEED AND	18-Discuss	0.00		0.80	0.00
927	Evaluate and Estimate Impa	0210	PERCEPTUAL SPEED AND	29-Data Gathering/ Digital	2.36		0.80	1.89
928	Evaluate and Estimate Impa	0220	REACTION TIME	14-Estimate Impact	0.00		0.80	0.00
929	Evaluate and Estimate Impa	0220	REACTION TIME	15-Data Gathering/ Analog	0.00		0.80	0.00
930	Evaluate and Estimate Impa	0220	REACTION TIME	16-Find Options	0.00		0.80	0.00
931	Evaluate and Estimate Impa	0220	REACTION TIME	17-Compare Alternatives	0.00		0.80	0.00
932	Evaluate and Estimate Impa	0220	REACTION TIME	18-Discuss	0.00		0.80	0.00
933	Evaluate and Estimate Impa	0220	REACTION TIME	29-Data Gathering/ Digital	0.00		0.80	0.00
934	Evaluate and Estimate Impa	0230	CHOICE REACTION TIME	14-Estimate Impact	0.00		0.80	0.00
935	Evaluate and Estimate Impa	0230	CHOICE REACTION TIME	15-Data Gathering/ Analog	0.00		0.80	0.00
936	Evaluate and Estimate Impa	0230	CHOICE REACTION TIME	16-Find Options	0.00		0.80	0.00
937	Evaluate and Estimate Impa	0230	CHOICE REACTION TIME	17-Compare Alternatives	0.00		0.80	0.00
938	Evaluate and Estimate Impa	0230	CHOICE REACTION TIME	18-Discuss	0.00		0.80	0.00
939	Evaluate and Estimate Impa	0230	CHOICE REACTION TIME	29-Data Gathering/ Digital	0.00		0.80	0.00
940	Evaluate and Estimate Impa	0240	NEAR VISION	14-Estimate Impact	1.19		0.80	0.95
941	Evaluate and Estimate Impa	0240	NEAR VISION	15-Data Gathering/ Analog	1.19		0.80	0.95
942	Evaluate and Estimate Impa	0240	NEAR VISION	16-Find Options	1.19		0.80	0.95
943	Evaluate and Estimate Impa	0240	NEAR VISION	17-Compare Alternatives	1.19		0.80	0.95
944	Evaluate and Estimate Impa	0240	NEAR VISION	18-Discuss	0.00		0.80	0.00
945	Evaluate and Estimate Impa	0240	NEAR VISION	29-Data Gathering/ Digital	1.19		0.80	0.95
946	Evaluate and Estimate Impa	0250	FAR VISION	14-Estimate Impact	0.00		0.80	0.00
947	Evaluate and Estimate Impa	0250	FAR VISION	15-Data Gathering/ Analog	0.00		0.80	0.00
948	Evaluate and Estimate Impa	0250	FAR VISION	16-Find Options	0.00		0.80	0.00
949	Evaluate and Estimate Impa	0250	FAR VISION	17-Compare Alternatives	0.00		0.80	0.00
950	Evaluate and Estimate Impa	0250	FAR VISION	18-Discuss	0.00		0.80	0.00
951	Evaluate and Estimate Impa	0250	FAR VISION	29-Data Gathering/ Digital	0.00		0.80	0.00
952	Evaluate and Estimate Impa	0260	NIGHT VISION	14-Estimate Impact	0.00		0.80	0.00
953	Evaluate and Estimate Impa	0260	NIGHT VISION	15-Data Gathering/ Analog	0.00		0.80	0.00
954	Evaluate and Estimate Impa	0260	NIGHT VISION	16-Find Options	0.00		0.80	0.00
955	Evaluate and Estimate Impa	0260	NIGHT VISION	17-Compare Alternatives	0.00		0.80	0.00

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	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
956	Evaluate and Estimate Impa	0260	NIGHT VISION	18-Discuss	0.00		0.80	0.00
957	Evaluate and Estimate Impa	0260	NIGHT VISION	29-Data Gathering/ Digital	0.00		0.80	0.00
958	Evaluate and Estimate Impa	0270	VISUAL COLOR DISCRIMIN	14-Estimate Impact	0.00		0.80	0.00
959	Evaluate and Estimate Impa	0270	VISUAL COLOR DISCRIMIN	15-Data Gathering/ Analog	0.00		0.80	0.00
960	Evaluate and Estimate Impa	0270	VISUAL COLOR DISCRIMIN	16-Find Options	0.00		0.80	0.00
961	Evaluate and Estimate Impa	0270	VISUAL COLOR DISCRIMIN	17-Compare Alternatives	0.00		0.80	0.00
962	Evaluate and Estimate Impa	0270	VISUAL COLOR DISCRIMIN	18-Discuss	0.00		0.80	0.00
963	Evaluate and Estimate Impa	0270	VISUAL COLOR DISCRIMIN	29-Data Gathering/ Digital	0.00		0.80	0.00
964	Evaluate and Estimate Impa	0280	PERIPHERAL VISION	14-Estimate Impact	0.00		0.80	0.00
965	Evaluate and Estimate Impa	0280	PERIPHERAL VISION	15-Data Gathering/ Analog	0.00		0.80	0.00
966	Evaluate and Estimate Impa	0280	PERIPHERAL VISION	16-Find Options	0.00		0.80	0.00
967	Evaluate and Estimate Impa	0280	PERIPHERAL VISION	17-Compare Alternatives	0.00		0.80	0.00
968	Evaluate and Estimate Impa	0280	PERIPHERAL VISION	18-Discuss	0.00		0.80	0.00
969	Evaluate and Estimate Impa	0280	PERIPHERAL VISION	29-Data Gathering/ Digital	0.00		0.80	0.00
970	Evaluate and Estimate Impa	0290	DEPTH PERCEPTION	14-Estimate Impact	0.00		0.80	0.00
971	Evaluate and Estimate Impa	0290	DEPTH PERCEPTION	15-Data Gathering/ Analog	0.00		0.80	0.00
972	Evaluate and Estimate Impa	0290	DEPTH PERCEPTION	16-Find Options	0.00		0.80	0.00
973	Evaluate and Estimate Impa	0290	DEPTH PERCEPTION	17-Compare Alternatives	0.00		0.80	0.00
974	Evaluate and Estimate Impa	0290	DEPTH PERCEPTION	18-Discuss	0.00		0.80	0.00
975	Evaluate and Estimate Impa	0290	DEPTH PERCEPTION	29-Data Gathering/ Digital	0.00		0.80	0.00
976	Evaluate and Estimate Impa	0300	GLARE SENSITIVITY	14-Estimate Impact	0.00		0.80	0.00
977	Evaluate and Estimate Impa	0300	GLARE SENSITIVITY	15-Data Gathering/ Analog	0.00		0.80	0.00
978	Evaluate and Estimate Impa	0300	GLARE SENSITIVITY	16-Find Options	0.00		0.80	0.00
979	Evaluate and Estimate Impa	0300	GLARE SENSITIVITY	17-Compare Alternatives	0.00		0.80	0.00
980	Evaluate and Estimate Impa	0300	GLARE SENSITIVITY	18-Discuss	0.00		0.80	0.00
981	Evaluate and Estimate Impa	0300	GLARE SENSITIVITY	29-Data Gathering/ Digital	0.00		0.80	0.00
982	Evaluate and Estimate Impa	0310	GENERAL HEARING	14-Estimate Impact	0.00		0.80	0.00
983	Evaluate and Estimate Impa	0310	GENERAL HEARING	15-Data Gathering/ Analog	0.00		0.80	0.00
984	Evaluate and Estimate Impa	0310	GENERAL HEARING	16-Find Options	0.00		0.80	0.00
985	Evaluate and Estimate Impa	0310	GENERAL HEARING	17-Compare Alternatives	0.00		0.80	0.00
986	Evaluate and Estimate Impa	0310	GENERAL HEARING	18-Discuss	0.00		0.80	0.00
987	Evaluate and Estimate Impa	0310	GENERAL HEARING	29-Data Gathering/ Digital	0.00		0.80	0.00
988	Evaluate and Estimate Impa	0320	AUDITORY ATTENTION	14-Estimate Impact	0.00		0.80	0.00
989	Evaluate and Estimate Impa	0320	AUDITORY ATTENTION	15-Data Gathering/ Analog	1.94		0.80	1.55
990	Evaluate and Estimate Impa	0320	AUDITORY ATTENTION	16-Find Options	1.94		0.80	1.55
991	Evaluate and Estimate Impa	0320	AUDITORY ATTENTION	17-Compare Alternatives	1.94		0.80	1.55
992	Evaluate and Estimate Impa	0320	AUDITORY ATTENTION	18-Discuss	1.94		0.80	1.55
993	Evaluate and Estimate Impa	0320	AUDITORY ATTENTION	29-Data Gathering/ Digital	1.94		0.80	1.55
994	Evaluate and Estimate Impa	0330	SOUND LOCALIZATION	14-Estimate Impact	0.00		0.80	0.00
995	Evaluate and Estimate Impa	0330	SOUND LOCALIZATION	15-Data Gathering/ Analog	0.00		0.80	0.00
996	Evaluate and Estimate Impa	0330	SOUND LOCALIZATION	16-Find Options	0.00		0.80	0.00
997	Evaluate and Estimate Impa	0330	SOUND LOCALIZATION	17-Compare Alternatives	0.00		0.80	0.00
998	Evaluate and Estimate Impa	0330	SOUND LOCALIZATION	18-Discuss	0.00		0.80	0.00
999	Evaluate and Estimate Impa	0330	SOUND LOCALIZATION	29-Data Gathering/ Digital	0.00		0.80	0.00
1000	Evaluate and Estimate Impa	0340	CONTROL PRECISION	14-Estimate Impact	0.00		0.80	0.00
1001	Evaluate and Estimate Impa	0340	CONTROL PRECISION	15-Data Gathering/ Analog	0.00		0.80	0.00
1002	Evaluate and Estimate Impa	0340	CONTROL PRECISION	16-Find Options	0.00		0.80	0.00
1003	Evaluate and Estimate Impa	0340	CONTROL PRECISION	17-Compare Alternatives	0.00		0.80	0.00
1004	Evaluate and Estimate Impa	0340	CONTROL PRECISION	18-Discuss	0.00		0.80	0.00
1005	Evaluate and Estimate Impa	0340	CONTROL PRECISION	29-Data Gathering/ Digital	0.00		0.80	0.00
1006	Evaluate and Estimate Impa	0350	RATE CONTROL	14-Estimate Impact	0.00		0.80	0.00
1007	Evaluate and Estimate Impa	0350	RATE CONTROL	15-Data Gathering/ Analog	0.00		0.80	0.00
1008	Evaluate and Estimate Impa	0350	RATE CONTROL	16-Find Options	0.00		0.80	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
1009	Evaluate and Estimate Impa	0350	RATE CONTROL	17-Compare Alternatives	0.00		0.80	0.00
1010	Evaluate and Estimate Impa	0350	RATE CONTROL	18-Discuss	0.00		0.80	0.00
1011	Evaluate and Estimate Impa	0350	RATE CONTROL	29-Data Gathering/ Digital	0.00		0.80	0.00
1012	Evaluate and Estimate Impa	0360	WRIST-FINGER SPEED	14-Estimate Impact	0.00		0.80	0.00
1013	Evaluate and Estimate Impa	0360	WRIST-FINGER SPEED	15-Data Gathering/ Analog	0.00		0.80	0.00
1014	Evaluate and Estimate Impa	0360	WRIST-FINGER SPEED	16-Find Options	0.00		0.80	0.00
1015	Evaluate and Estimate Impa	0360	WRIST-FINGER SPEED	17-Compare Alternatives	0.00		0.80	0.00
1016	Evaluate and Estimate Impa	0360	WRIST-FINGER SPEED	18-Discuss	0.00		0.80	0.00
1017	Evaluate and Estimate Impa	0360	WRIST-FINGER SPEED	29-Data Gathering/ Digital	1.00		0.80	0.80
1018	Evaluate and Estimate Impa	0370	FINGER DEXTERITY	14-Estimate Impact	0.00		0.80	0.00
1019	Evaluate and Estimate Impa	0370	FINGER DEXTERITY	15-Data Gathering/ Analog	0.00		0.80	0.00
1020	Evaluate and Estimate Impa	0370	FINGER DEXTERITY	16-Find Options	0.00		0.80	0.00
1021	Evaluate and Estimate Impa	0370	FINGER DEXTERITY	17-Compare Alternatives	0.00		0.80	0.00
1022	Evaluate and Estimate Impa	0370	FINGER DEXTERITY	18-Discuss	0.00		0.80	0.00
1023	Evaluate and Estimate Impa	0370	FINGER DEXTERITY	29-Data Gathering/ Digital	1.03		0.80	0.82
1024	Evaluate and Estimate Impa	0380	MANUAL DEXTERITY	14-Estimate Impact	0.00		0.80	0.00
1025	Evaluate and Estimate Impa	0380	MANUAL DEXTERITY	15-Data Gathering/ Analog	0.00		0.80	0.00
1026	Evaluate and Estimate Impa	0380	MANUAL DEXTERITY	16-Find Options	0.00		0.80	0.00
1027	Evaluate and Estimate Impa	0380	MANUAL DEXTERITY	17-Compare Alternatives	0.00		0.80	0.00
1028	Evaluate and Estimate Impa	0380	MANUAL DEXTERITY	18-Discuss	0.00		0.80	0.00
1029	Evaluate and Estimate Impa	0380	MANUAL DEXTERITY	29-Data Gathering/ Digital	1.21		0.80	0.97
1030	Evaluate and Estimate Impa	0390	ARM-HAND STEADINESS	14-Estimate Impact	0.00		0.80	0.00
1031	Evaluate and Estimate Impa	0390	ARM-HAND STEADINESS	15-Data Gathering/ Analog	0.00		0.80	0.00
1032	Evaluate and Estimate Impa	0390	ARM-HAND STEADINESS	16-Find Options	0.00		0.80	0.00
1033	Evaluate and Estimate Impa	0390	ARM-HAND STEADINESS	17-Compare Alternatives	0.00		0.80	0.00
1034	Evaluate and Estimate Impa	0390	ARM-HAND STEADINESS	18-Discuss	0.00		0.80	0.00
1035	Evaluate and Estimate Impa	0390	ARM-HAND STEADINESS	29-Data Gathering/ Digital	0.00		0.80	0.00
1036	Evaluate and Estimate Impa	0400	MULTI-LIMB COORDINATI	14-Estimate Impact	0.00		0.80	0.00
1037	Evaluate and Estimate Impa	0400	MULTI-LIMB COORDINATI	15-Data Gathering/ Analog	0.00		0.80	0.00
1038	Evaluate and Estimate Impa	0400	MULTI-LIMB COORDINATI	16-Find Options	0.00		0.80	0.00
1039	Evaluate and Estimate Impa	0400	MULTI-LIMB COORDINATI	17-Compare Alternatives	0.00		0.80	0.00
1040	Evaluate and Estimate Impa	0400	MULTI-LIMB COORDINATI	18-Discuss	0.00		0.80	0.00
1041	Evaluate and Estimate Impa	0400	MULTI-LIMB COORDINATI	29-Data Gathering/ Digital	0.00		0.80	0.00
1042	Evaluate and Estimate Impa	0410	EXTENT FLEXIBILITY	14-Estimate Impact	0.00		0.80	0.00
1043	Evaluate and Estimate Impa	0410	EXTENT FLEXIBILITY	15-Data Gathering/ Analog	0.00		0.80	0.00
1044	Evaluate and Estimate Impa	0410	EXTENT FLEXIBILITY	16-Find Options	0.00		0.80	0.00
1045	Evaluate and Estimate Impa	0410	EXTENT FLEXIBILITY	17-Compare Alternatives	0.00		0.80	0.00
1046	Evaluate and Estimate Impa	0410	EXTENT FLEXIBILITY	18-Discuss	0.00		0.80	0.00
1047	Evaluate and Estimate Impa	0410	EXTENT FLEXIBILITY	29-Data Gathering/ Digital	0.00		0.80	0.00
1048	Evaluate and Estimate Impa	0420	DYNAMIC FLEXIBILITY	14-Estimate Impact	0.00		0.80	0.00
1049	Evaluate and Estimate Impa	0420	DYNAMIC FLEXIBILITY	15-Data Gathering/ Analog	0.00		0.80	0.00
1050	Evaluate and Estimate Impa	0420	DYNAMIC FLEXIBILITY	16-Find Options	0.00		0.80	0.00
1051	Evaluate and Estimate Impa	0420	DYNAMIC FLEXIBILITY	17-Compare Alternatives	0.00		0.80	0.00
1052	Evaluate and Estimate Impa	0420	DYNAMIC FLEXIBILITY	18-Discuss	0.00		0.80	0.00
1053	Evaluate and Estimate Impa	0420	DYNAMIC FLEXIBILITY	29-Data Gathering/ Digital	0.00		0.80	0.00
1054	Evaluate and Estimate Impa	0430	SPEED OF LIMB MOVEMEI	14-Estimate Impact	0.00		0.80	0.00
1055	Evaluate and Estimate Impa	0430	SPEED OF LIMB MOVEMEI	15-Data Gathering/ Analog	0.00		0.80	0.00
1056	Evaluate and Estimate Impa	0430	SPEED OF LIMB MOVEMEI	16-Find Options	0.00		0.80	0.00
1057	Evaluate and Estimate Impa	0430	SPEED OF LIMB MOVEMEI	17-Compare Alternatives	0.00		0.80	0.00
1058	Evaluate and Estimate Impa	0430	SPEED OF LIMB MOVEMEI	18-Discuss	0.00		0.80	0.00
1059	Evaluate and Estimate Impa	0430	SPEED OF LIMB MOVEMEI	29-Data Gathering/ Digital	0.00		0.80	0.00
1060	Evaluate and Estimate Impa	0440	GROSS BODY EQUILIBRIU	14-Estimate Impact	0.00		0.80	0.00
1061	Evaluate and Estimate Impa	0440	GROSS BODY EQUILIBRIU	15-Data Gathering/ Analog	0.00		0.80	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
1062	Evaluate and Estimate Impa	0440	GROSS BODY EQUILIBRIU	16-Find Options	0.00		0.80	0.00
1063	Evaluate and Estimate Impa	0440	GROSS BODY EQUILIBRIU	17-Compare Alternatives	0.00		0.80	0.00
1064	Evaluate and Estimate Impa	0440	GROSS BODY EQUILIBRIU	18-Discuss	0.00		0.80	0.00
1065	Evaluate and Estimate Impa	0440	GROSS BODY EQUILIBRIU	29-Data Gathering/ Digital	0.00		0.80	0.00
1066	Evaluate and Estimate Impa	0450	GROSS BODY COORDINA	14-Estimate Impact	0.00		0.80	0.00
1067	Evaluate and Estimate Impa	0450	GROSS BODY COORDINA	15-Data Gathering/ Analog	0.00		0.80	0.00
1068	Evaluate and Estimate Impa	0450	GROSS BODY COORDINA	16-Find Options	0.00		0.80	0.00
1069	Evaluate and Estimate Impa	0450	GROSS BODY COORDINA	17-Compare Alternatives	0.00		0.80	0.00
1070	Evaluate and Estimate Impa	0450	GROSS BODY COORDINA	18-Discuss	0.00		0.80	0.00
1071	Evaluate and Estimate Impa	0450	GROSS BODY COORDINA	29-Data Gathering/ Digital	0.00		0.80	0.00
1072	Evaluate and Estimate Impa	0460	STATIC STRENGTH	14-Estimate Impact	0.00		0.80	0.00
1073	Evaluate and Estimate Impa	0460	STATIC STRENGTH	15-Data Gathering/ Analog	0.00		0.80	0.00
1074	Evaluate and Estimate Impa	0460	STATIC STRENGTH	16-Find Options	0.00		0.80	0.00
1075	Evaluate and Estimate Impa	0460	STATIC STRENGTH	17-Compare Alternatives	0.00		0.80	0.00
1076	Evaluate and Estimate Impa	0460	STATIC STRENGTH	18-Discuss	0.00		0.80	0.00
1077	Evaluate and Estimate Impa	0460	STATIC STRENGTH	29-Data Gathering/ Digital	0.00		0.80	0.00
1078	Evaluate and Estimate Impa	0470	EXPLOSIVE STRENGTH	14-Estimate Impact	0.00		0.80	0.00
1079	Evaluate and Estimate Impa	0470	EXPLOSIVE STRENGTH	15-Data Gathering/ Analog	0.00		0.80	0.00
1080	Evaluate and Estimate Impa	0470	EXPLOSIVE STRENGTH	16-Find Options	0.00		0.80	0.00
1081	Evaluate and Estimate Impa	0470	EXPLOSIVE STRENGTH	17-Compare Alternatives	0.00		0.80	0.00
1082	Evaluate and Estimate Impa	0470	EXPLOSIVE STRENGTH	18-Discuss	0.00		0.80	0.00
1083	Evaluate and Estimate Impa	0470	EXPLOSIVE STRENGTH	29-Data Gathering/ Digital	0.00		0.80	0.00
1084	Evaluate and Estimate Impa	0480	DYNAMIC STRENGTH	14-Estimate Impact	0.00		0.80	0.00
1085	Evaluate and Estimate Impa	0480	DYNAMIC STRENGTH	15-Data Gathering/ Analog	0.00		0.80	0.00
1086	Evaluate and Estimate Impa	0480	DYNAMIC STRENGTH	16-Find Options	0.00		0.80	0.00
1087	Evaluate and Estimate Impa	0480	DYNAMIC STRENGTH	17-Compare Alternatives	0.00		0.80	0.00
1088	Evaluate and Estimate Impa	0480	DYNAMIC STRENGTH	18-Discuss	0.00		0.80	0.00
1089	Evaluate and Estimate Impa	0480	DYNAMIC STRENGTH	29-Data Gathering/ Digital	0.00		0.80	0.00
1090	Evaluate and Estimate Impa	0490	TRUNK STRENGTH	14-Estimate Impact	0.00		0.80	0.00
1091	Evaluate and Estimate Impa	0490	TRUNK STRENGTH	15-Data Gathering/ Analog	0.00		0.80	0.00
1092	Evaluate and Estimate Impa	0490	TRUNK STRENGTH	16-Find Options	0.00		0.80	0.00
1093	Evaluate and Estimate Impa	0490	TRUNK STRENGTH	17-Compare Alternatives	0.00		0.80	0.00
1094	Evaluate and Estimate Impa	0490	TRUNK STRENGTH	18-Discuss	0.00		0.80	0.00
1095	Evaluate and Estimate Impa	0490	TRUNK STRENGTH	29-Data Gathering/ Digital	0.00		0.80	0.00
1096	Evaluate and Estimate Impa	0500	STAMINA	14-Estimate Impact	0.00		0.80	0.00
1097	Evaluate and Estimate Impa	0500	STAMINA	15-Data Gathering/ Analog	0.00		0.80	0.00
1098	Evaluate and Estimate Impa	0500	STAMINA	16-Find Options	0.00		0.80	0.00
1099	Evaluate and Estimate Impa	0500	STAMINA	17-Compare Alternatives	0.00		0.80	0.00
1100	Evaluate and Estimate Impa	0500	STAMINA	18-Discuss	0.00		0.80	0.00
1101	Evaluate and Estimate Impa	0500	STAMINA	29-Data Gathering/ Digital	0.00		0.80	0.00
1102	Identify/Understand Situatio	0010	ORAL COMPREHENSION	19-Read/Analog	0.00		0.80	0.00
1103	Identify/Understand Situatio	0010	ORAL COMPREHENSION	20-Scan	0.00		0.80	0.00
1104	Identify/Understand Situatio	0010	ORAL COMPREHENSION	21-Update/ Analog	0.00		0.80	0.00
1105	Identify/Understand Situatio	0010	ORAL COMPREHENSION	22-Check Status	0.00		0.80	0.00
1106	Identify/Understand Situatio	0010	ORAL COMPREHENSION	23-Problem Definition	2.15		0.80	1.72
1107	Identify/Understand Situatio	0010	ORAL COMPREHENSION	24-Listen/Monitor - Analog	2.15		0.80	1.72
1108	Identify/Understand Situatio	0010	ORAL COMPREHENSION	30-Read/ Digital	0.00		0.80	0.00
1109	Identify/Understand Situatio	0010	ORAL COMPREHENSION	31-Scan Digital	0.00		0.80	0.00
1110	Identify/Understand Situatio	0010	ORAL COMPREHENSION	32-Monitor Digital	0.00		0.80	0.00
1111	Identify/Understand Situatio	0020	WRITTEN COMPREHENSIC	19-Read/Analog	1.64		0.80	1.31
1112	Identify/Understand Situatio	0020	WRITTEN COMPREHENSIC	20-Scan	1.64		0.80	1.31
1113	Identify/Understand Situatio	0020	WRITTEN COMPREHENSIC	21-Update/ Analog	1.64		0.80	1.31
1114	Identify/Understand Situatio	0020	WRITTEN COMPREHENSIC	22-Check Status	1.64		0.80	1.31

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
1115	Identify/Understand Situatio	0020	WRITTEN COMPREHENSIC	23-Problem Definition	1.64		0.80	1.31
1116	Identify/Understand Situatio	0020	WRITTEN COMPREHENSIC	24-Listen/Monitor - Analog	0.00		0.80	0.00
1117	Identify/Understand Situatio	0020	WRITTEN COMPREHENSIC	30-Read/ Digital	1.64		0.80	1.31
1118	Identify/Understand Situatio	0020	WRITTEN COMPREHENSIC	31-Scan Digital	1.64		0.80	1.31
1119	Identify/Understand Situatio	0020	WRITTEN COMPREHENSIC	32-Monitor Digital	1.64		0.80	1.31
1120	Identify/Understand Situatio	0030	ORAL EXPRESSION	19-Read/Analog	0.00		0.80	0.00
1121	Identify/Understand Situatio	0030	ORAL EXPRESSION	20-Scan	0.00		0.80	0.00
1122	Identify/Understand Situatio	0030	ORAL EXPRESSION	21-Update/ Analog	0.00		0.80	0.00
1123	Identify/Understand Situatio	0030	ORAL EXPRESSION	22-Check Status	0.00		0.80	0.00
1124	Identify/Understand Situatio	0030	ORAL EXPRESSION	23-Problem Definition	2.49		0.80	1.99
1125	Identify/Understand Situatio	0030	ORAL EXPRESSION	24-Listen/Monitor - Analog	0.00		0.80	0.00
1126	Identify/Understand Situatio	0030	ORAL EXPRESSION	30-Read/ Digital	0.00		0.80	0.00
1127	Identify/Understand Situatio	0030	ORAL EXPRESSION	31-Scan Digital	0.00		0.80	0.00
1128	Identify/Understand Situatio	0030	ORAL EXPRESSION	32-Monitor Digital	0.00		0.80	0.00
1129	Identify/Understand Situatio	0040	WRITTEN EXPRESSION	19-Read/Analog	0.00		0.80	0.00
1130	Identify/Understand Situatio	0040	WRITTEN EXPRESSION	20-Scan	0.00		0.80	0.00
1131	Identify/Understand Situatio	0040	WRITTEN EXPRESSION	21-Update/ Analog	0.00		0.80	0.00
1132	Identify/Understand Situatio	0040	WRITTEN EXPRESSION	22-Check Status	0.00		0.80	0.00
1133	Identify/Understand Situatio	0040	WRITTEN EXPRESSION	23-Problem Definition	0.00		0.80	0.00
1134	Identify/Understand Situatio	0040	WRITTEN EXPRESSION	24-Listen/Monitor - Analog	0.00		0.80	0.00
1135	Identify/Understand Situatio	0040	WRITTEN EXPRESSION	30-Read/ Digital	0.00		0.80	0.00
1136	Identify/Understand Situatio	0040	WRITTEN EXPRESSION	31-Scan Digital	0.00		0.80	0.00
1137	Identify/Understand Situatio	0040	WRITTEN EXPRESSION	32-Monitor Digital	0.00		0.80	0.00
1138	Identify/Understand Situatio	0050	MEMORIZATION	19-Read/Analog	0.00		0.80	0.00
1139	Identify/Understand Situatio	0050	MEMORIZATION	20-Scan	2.34		0.80	1.87
1140	Identify/Understand Situatio	0050	MEMORIZATION	21-Update/ Analog	2.34		0.80	1.87
1141	Identify/Understand Situatio	0050	MEMORIZATION	22-Check Status	2.34		0.80	1.87
1142	Identify/Understand Situatio	0050	MEMORIZATION	23-Problem Definition	2.34		0.80	1.87
1143	Identify/Understand Situatio	0050	MEMORIZATION	24-Listen/Monitor - Analog	2.34		0.80	1.87
1144	Identify/Understand Situatio	0050	MEMORIZATION	30-Read/ Digital	2.34		0.80	1.87
1145	Identify/Understand Situatio	0050	MEMORIZATION	31-Scan Digital	2.34		0.80	1.87
1146	Identify/Understand Situatio	0050	MEMORIZATION	32-Monitor Digital	2.34		0.80	1.87
1147	Identify/Understand Situatio	0060	PROBLEM SENSITIVITY	19-Read/Analog	0.00		0.80	0.00
1148	Identify/Understand Situatio	0060	PROBLEM SENSITIVITY	20-Scan	2.10		0.80	1.68
1149	Identify/Understand Situatio	0060	PROBLEM SENSITIVITY	21-Update/ Analog	0.00		0.80	0.00
1150	Identify/Understand Situatio	0060	PROBLEM SENSITIVITY	22-Check Status	2.10		0.80	1.68
1151	Identify/Understand Situatio	0060	PROBLEM SENSITIVITY	23-Problem Definition	2.10		0.80	1.68
1152	Identify/Understand Situatio	0060	PROBLEM SENSITIVITY	24-Listen/Monitor - Analog	0.00		0.80	0.00
1153	Identify/Understand Situatio	0060	PROBLEM SENSITIVITY	30-Read/ Digital	0.00		0.80	0.00
1154	Identify/Understand Situatio	0060	PROBLEM SENSITIVITY	31-Scan Digital	0.00		0.80	0.00
1155	Identify/Understand Situatio	0060	PROBLEM SENSITIVITY	32-Monitor Digital	2.10		0.80	1.68
1156	Identify/Understand Situatio	0070	ORIGINALITY	19-Read/Analog	0.00		0.80	0.00
1157	Identify/Understand Situatio	0070	ORIGINALITY	20-Scan	0.00		0.80	0.00
1158	Identify/Understand Situatio	0070	ORIGINALITY	21-Update/ Analog	0.00		0.80	0.00
1159	Identify/Understand Situatio	0070	ORIGINALITY	22-Check Status	0.00		0.80	0.00
1160	Identify/Understand Situatio	0070	ORIGINALITY	23-Problem Definition	0.00		0.80	0.00
1161	Identify/Understand Situatio	0070	ORIGINALITY	24-Listen/Monitor - Analog	0.00		0.80	0.00
1162	Identify/Understand Situatio	0070	ORIGINALITY	30-Read/ Digital	0.00		0.80	0.00
1163	Identify/Understand Situatio	0070	ORIGINALITY	31-Scan Digital	0.00		0.80	0.00
1164	Identify/Understand Situatio	0070	ORIGINALITY	32-Monitor Digital	0.00		0.80	0.00
1165	Identify/Understand Situatio	0080	FLUENCY OF IDEAS	19-Read/Analog	0.00		0.80	0.00
1166	Identify/Understand Situatio	0080	FLUENCY OF IDEAS	20-Scan	0.00		0.80	0.00
1167	Identify/Understand Situatio	0080	FLUENCY OF IDEAS	21-Update/ Analog	0.00		0.80	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
1168	Identify/Understand Situatio	0080	FLUENCY OF IDEAS	22-Check Status	0.00		0.80	0.00
1169	Identify/Understand Situatio	0080	FLUENCY OF IDEAS	23-Problem Definition	0.00		0.80	0.00
1170	Identify/Understand Situatio	0080	FLUENCY OF IDEAS	24-Listen/Monitor - Analog	0.00		0.80	0.00
1171	Identify/Understand Situatio	0080	FLUENCY OF IDEAS	30-Read/ Digital	0.00		0.80	0.00
1172	Identify/Understand Situatio	0080	FLUENCY OF IDEAS	31-Scan Digital	0.00		0.80	0.00
1173	Identify/Understand Situatio	0080	FLUENCY OF IDEAS	32-Monitor Digital	0.00		0.80	0.00
1174	Identify/Understand Situatio	0090	FLEXIBILITY OF CLOSURE	19-Read/Analog	0.00		0.80	0.00
1175	Identify/Understand Situatio	0090	FLEXIBILITY OF CLOSURE	20-Scan	1.49		0.80	1.19
1176	Identify/Understand Situatio	0090	FLEXIBILITY OF CLOSURE	21-Update/ Analog	0.00		0.80	0.00
1177	Identify/Understand Situatio	0090	FLEXIBILITY OF CLOSURE	22-Check Status	1.49		0.80	1.19
1178	Identify/Understand Situatio	0090	FLEXIBILITY OF CLOSURE	23-Problem Definition	0.00		0.80	0.00
1179	Identify/Understand Situatio	0090	FLEXIBILITY OF CLOSURE	24-Listen/Monitor - Analog	0.00		0.80	0.00
1180	Identify/Understand Situatio	0090	FLEXIBILITY OF CLOSURE	30-Read/ Digital	0.00		0.80	0.00
1181	Identify/Understand Situatio	0090	FLEXIBILITY OF CLOSURE	31-Scan Digital	0.00		0.80	0.00
1182	Identify/Understand Situatio	0090	FLEXIBILITY OF CLOSURE	32-Monitor Digital	1.49		0.80	1.19
1183	Identify/Understand Situatio	0100	SELECTIVE ATTENTION	19-Read/Analog	1.50		0.80	1.20
1184	Identify/Understand Situatio	0100	SELECTIVE ATTENTION	20-Scan	1.50		0.80	1.20
1185	Identify/Understand Situatio	0100	SELECTIVE ATTENTION	21-Update/ Analog	1.50		0.80	1.20
1186	Identify/Understand Situatio	0100	SELECTIVE ATTENTION	22-Check Status	1.50		0.80	1.20
1187	Identify/Understand Situatio	0100	SELECTIVE ATTENTION	23-Problem Definition	1.50		0.80	1.20
1188	Identify/Understand Situatio	0100	SELECTIVE ATTENTION	24-Listen/Monitor - Analog	1.50		0.80	1.20
1189	Identify/Understand Situatio	0100	SELECTIVE ATTENTION	30-Read/ Digital	1.50		0.80	1.20
1190	Identify/Understand Situatio	0100	SELECTIVE ATTENTION	31-Scan Digital	1.50		0.80	1.20
1191	Identify/Understand Situatio	0100	SELECTIVE ATTENTION	32-Monitor Digital	1.50		0.80	1.20
1192	Identify/Understand Situatio	0110	SPATIAL ORIENTATION	19-Read/Analog	0.00		0.80	0.00
1193	Identify/Understand Situatio	0110	SPATIAL ORIENTATION	20-Scan	0.00		0.80	0.00
1194	Identify/Understand Situatio	0110	SPATIAL ORIENTATION	21-Update/ Analog	0.00		0.80	0.00
1195	Identify/Understand Situatio	0110	SPATIAL ORIENTATION	22-Check Status	0.00		0.80	0.00
1196	Identify/Understand Situatio	0110	SPATIAL ORIENTATION	23-Problem Definition	0.00		0.80	0.00
1197	Identify/Understand Situatio	0110	SPATIAL ORIENTATION	24-Listen/Monitor - Analog	0.00		0.80	0.00
1198	Identify/Understand Situatio	0110	SPATIAL ORIENTATION	30-Read/ Digital	0.00		0.80	0.00
1199	Identify/Understand Situatio	0110	SPATIAL ORIENTATION	31-Scan Digital	0.00		0.80	0.00
1200	Identify/Understand Situatio	0110	SPATIAL ORIENTATION	32-Monitor Digital	0.00		0.80	0.00
1201	Identify/Understand Situatio	0120	VISUALIZATION	19-Read/Analog	0.00		0.80	0.00
1202	Identify/Understand Situatio	0120	VISUALIZATION	20-Scan	2.18		0.80	1.74
1203	Identify/Understand Situatio	0120	VISUALIZATION	21-Update/ Analog	0.00		0.80	0.00
1204	Identify/Understand Situatio	0120	VISUALIZATION	22-Check Status	2.18		0.80	1.74
1205	Identify/Understand Situatio	0120	VISUALIZATION	23-Problem Definition	2.18		0.80	1.74
1206	Identify/Understand Situatio	0120	VISUALIZATION	24-Listen/Monitor - Analog	0.00		0.80	0.00
1207	Identify/Understand Situatio	0120	VISUALIZATION	30-Read/ Digital	0.00		0.80	0.00
1208	Identify/Understand Situatio	0120	VISUALIZATION	31-Scan Digital	0.00		0.80	0.00
1209	Identify/Understand Situatio	0120	VISUALIZATION	32-Monitor Digital	2.18		0.80	1.74
1210	Identify/Understand Situatio	0130	INDUCTIVE REASONING	19-Read/Analog	0.00		0.80	0.00
1211	Identify/Understand Situatio	0130	INDUCTIVE REASONING	20-Scan	2.59		0.80	2.07
1212	Identify/Understand Situatio	0130	INDUCTIVE REASONING	21-Update/ Analog	0.00		0.80	0.00
1213	Identify/Understand Situatio	0130	INDUCTIVE REASONING	22-Check Status	2.59		0.80	2.07
1214	Identify/Understand Situatio	0130	INDUCTIVE REASONING	23-Problem Definition	2.59		0.80	2.07
1215	Identify/Understand Situatio	0130	INDUCTIVE REASONING	24-Listen/Monitor - Analog	0.00		0.80	0.00
1216	Identify/Understand Situatio	0130	INDUCTIVE REASONING	30-Read/ Digital	0.00		0.80	0.00
1217	Identify/Understand Situatio	0130	INDUCTIVE REASONING	31-Scan Digital	0.00		0.80	0.00
1218	Identify/Understand Situatio	0130	INDUCTIVE REASONING	32-Monitor Digital	2.59		0.80	2.07
1219	Identify/Understand Situatio	0140	CATEGORY FLEXIBILITY	19-Read/Analog	0.00		0.80	0.00
1220	Identify/Understand Situatio	0140	CATEGORY FLEXIBILITY	20-Scan	0.00		0.80	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
1221	Identify/Understand Situatio	0140	CATEGORY FLEXIBILITY	21-Update/ Analog	0.00		0.80	0.00
1222	Identify/Understand Situatio	0140	CATEGORY FLEXIBILITY	22-Check Status	0.00		0.80	0.00
1223	Identify/Understand Situatio	0140	CATEGORY FLEXIBILITY	23-Problem Definition	0.00		0.80	0.00
1224	Identify/Understand Situatio	0140	CATEGORY FLEXIBILITY	24-Listen/Monitor - Analog	0.00		0.80	0.00
1225	Identify/Understand Situatio	0140	CATEGORY FLEXIBILITY	30-Read/ Digital	0.00		0.80	0.00
1226	Identify/Understand Situatio	0140	CATEGORY FLEXIBILITY	31-Scan Digital	0.00		0.80	0.00
1227	Identify/Understand Situatio	0140	CATEGORY FLEXIBILITY	32-Monitor Digital	2.58		0.80	2.06
1228	Identify/Understand Situatio	0150	DEDUCTIVE REASONING	19-Read/Analog	0.00		0.80	0.00
1229	Identify/Understand Situatio	0150	DEDUCTIVE REASONING	20-Scan	2.71		0.80	2.17
1230	Identify/Understand Situatio	0150	DEDUCTIVE REASONING	21-Update/ Analog	0.00		0.80	0.00
1231	Identify/Understand Situatio	0150	DEDUCTIVE REASONING	22-Check Status	2.71		0.80	2.17
1232	Identify/Understand Situatio	0150	DEDUCTIVE REASONING	23-Problem Definition	0.00		0.80	0.00
1233	Identify/Understand Situatio	0150	DEDUCTIVE REASONING	24-Listen/Monitor - Analog	0.00		0.80	0.00
1234	Identify/Understand Situatio	0150	DEDUCTIVE REASONING	30-Read/ Digital	0.00		0.80	0.00
1235	Identify/Understand Situatio	0150	DEDUCTIVE REASONING	31-Scan Digital	0.00		0.80	0.00
1236	Identify/Understand Situatio	0150	DEDUCTIVE REASONING	32-Monitor Digital	2.71		0.80	2.17
1237	Identify/Understand Situatio	0160	INFORMATION ORDERING	19-Read/Analog	0.00		0.80	0.00
1238	Identify/Understand Situatio	0160	INFORMATION ORDERING	20-Scan	0.00		0.80	0.00
1239	Identify/Understand Situatio	0160	INFORMATION ORDERING	21-Update/ Analog	2.89		0.80	2.31
1240	Identify/Understand Situatio	0160	INFORMATION ORDERING	22-Check Status	2.89		0.80	2.31
1241	Identify/Understand Situatio	0160	INFORMATION ORDERING	23-Problem Definition	2.89		0.80	2.31
1242	Identify/Understand Situatio	0160	INFORMATION ORDERING	24-Listen/Monitor - Analog	0.00		0.80	0.00
1243	Identify/Understand Situatio	0160	INFORMATION ORDERING	30-Read/ Digital	0.00		0.80	0.00
1244	Identify/Understand Situatio	0160	INFORMATION ORDERING	31-Scan Digital	0.00		0.80	0.00
1245	Identify/Understand Situatio	0160	INFORMATION ORDERING	32-Monitor Digital	2.89		0.80	2.31
1246	Identify/Understand Situatio	0170	MATHEMATICAL REASONI	19-Read/Analog	0.00		0.80	0.00
1247	Identify/Understand Situatio	0170	MATHEMATICAL REASONI	20-Scan	2.14		0.80	1.71
1248	Identify/Understand Situatio	0170	MATHEMATICAL REASONI	21-Update/ Analog	0.00		0.80	0.00
1249	Identify/Understand Situatio	0170	MATHEMATICAL REASONI	22-Check Status	2.14		0.80	1.71
1250	Identify/Understand Situatio	0170	MATHEMATICAL REASONI	23-Problem Definition	0.00		0.80	0.00
1251	Identify/Understand Situatio	0170	MATHEMATICAL REASONI	24-Listen/Monitor - Analog	0.00		0.80	0.00
1252	Identify/Understand Situatio	0170	MATHEMATICAL REASONI	30-Read/ Digital	0.00		0.80	0.00
1253	Identify/Understand Situatio	0170	MATHEMATICAL REASONI	31-Scan Digital	0.00		0.80	0.00
1254	Identify/Understand Situatio	0170	MATHEMATICAL REASONI	32-Monitor Digital	2.14		0.80	1.71
1255	Identify/Understand Situatio	0180	NUMBER FACILITY	19-Read/Analog	0.00		0.80	0.00
1256	Identify/Understand Situatio	0180	NUMBER FACILITY	20-Scan	2.50		0.80	2.00
1257	Identify/Understand Situatio	0180	NUMBER FACILITY	21-Update/ Analog	0.00		0.80	0.00
1258	Identify/Understand Situatio	0180	NUMBER FACILITY	22-Check Status	0.00		0.80	0.00
1259	Identify/Understand Situatio	0180	NUMBER FACILITY	23-Problem Definition	0.00		0.80	0.00
1260	Identify/Understand Situatio	0180	NUMBER FACILITY	24-Listen/Monitor - Analog	0.00		0.80	0.00
1261	Identify/Understand Situatio	0180	NUMBER FACILITY	30-Read/ Digital	0.00		0.80	0.00
1262	Identify/Understand Situatio	0180	NUMBER FACILITY	31-Scan Digital	0.00		0.80	0.00
1263	Identify/Understand Situatio	0180	NUMBER FACILITY	32-Monitor Digital	2.50		0.80	2.00
1264	Identify/Understand Situatio	0190	TIME SHARING	19-Read/Analog	2.00		0.80	1.60
1265	Identify/Understand Situatio	0190	TIME SHARING	20-Scan	2.00		0.80	1.60
1266	Identify/Understand Situatio	0190	TIME SHARING	21-Update/ Analog	2.00		0.80	1.60
1267	Identify/Understand Situatio	0190	TIME SHARING	22-Check Status	2.00		0.80	1.60
1268	Identify/Understand Situatio	0190	TIME SHARING	23-Problem Definition	2.00		0.80	1.60
1269	Identify/Understand Situatio	0190	TIME SHARING	24-Listen/Monitor - Analog	2.00		0.80	1.60
1270	Identify/Understand Situatio	0190	TIME SHARING	30-Read/ Digital	2.00		0.80	1.60
1271	Identify/Understand Situatio	0190	TIME SHARING	31-Scan Digital	2.00		0.80	1.60
1272	Identify/Understand Situatio	0190	TIME SHARING	32-Monitor Digital	2.00		0.80	1.60
1273	Identify/Understand Situatio	0200	SPEED OF CLOSURE	19-Read/Analog	0.00		0.80	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
1274	Identify/Understand Situatio	0200	SPEED OF CLOSURE	20-Scan	2.22		0.80	1.78
1275	Identify/Understand Situatio	0200	SPEED OF CLOSURE	21-Update/ Analog	0.00		0.80	0.00
1276	Identify/Understand Situatio	0200	SPEED OF CLOSURE	22-Check Status	2.22		0.80	1.78
1277	Identify/Understand Situatio	0200	SPEED OF CLOSURE	23-Problem Definition	2.22		0.80	1.78
1278	Identify/Understand Situatio	0200	SPEED OF CLOSURE	24-Listen/Monitor - Analog	2.22		0.80	1.78
1279	Identify/Understand Situatio	0200	SPEED OF CLOSURE	30-Read/ Digital	0.00		0.80	0.00
1280	Identify/Understand Situatio	0200	SPEED OF CLOSURE	31-Scan Digital	0.00		0.80	0.00
1281	Identify/Understand Situatio	0200	SPEED OF CLOSURE	32-Monitor Digital	2.22		0.80	1.78
1282	Identify/Understand Situatio	0210	PERCEPTUAL SPEED AND	19-Read/Analog	0.00		0.80	0.00
1283	Identify/Understand Situatio	0210	PERCEPTUAL SPEED AND	20-Scan	2.36		0.80	1.89
1284	Identify/Understand Situatio	0210	PERCEPTUAL SPEED AND	21-Update/ Analog	2.36		0.80	1.89
1285	Identify/Understand Situatio	0210	PERCEPTUAL SPEED AND	22-Check Status	2.36		0.80	1.89
1286	Identify/Understand Situatio	0210	PERCEPTUAL SPEED AND	23-Problem Definition	0.00		0.80	0.00
1287	Identify/Understand Situatio	0210	PERCEPTUAL SPEED AND	24-Listen/Monitor - Analog	2.36		0.80	1.89
1288	Identify/Understand Situatio	0210	PERCEPTUAL SPEED AND	30-Read/ Digital	0.00		0.80	0.00
1289	Identify/Understand Situatio	0210	PERCEPTUAL SPEED AND	31-Scan Digital	0.00		0.80	0.00
1290	Identify/Understand Situatio	0210	PERCEPTUAL SPEED AND	32-Monitor Digital	2.36		0.80	1.89
1291	Identify/Understand Situatio	0220	REACTION TIME	19-Read/Analog	0.00		0.80	0.00
1292	Identify/Understand Situatio	0220	REACTION TIME	20-Scan	0.00		0.80	0.00
1293	Identify/Understand Situatio	0220	REACTION TIME	21-Update/ Analog	0.00		0.80	0.00
1294	Identify/Understand Situatio	0220	REACTION TIME	22-Check Status	0.00		0.80	0.00
1295	Identify/Understand Situatio	0220	REACTION TIME	23-Problem Definition	0.00		0.80	0.00
1296	Identify/Understand Situatio	0220	REACTION TIME	24-Listen/Monitor - Analog	0.00		0.80	0.00
1297	Identify/Understand Situatio	0220	REACTION TIME	30-Read/ Digital	0.00		0.80	0.00
1298	Identify/Understand Situatio	0220	REACTION TIME	31-Scan Digital	0.00		0.80	0.00
1299	Identify/Understand Situatio	0220	REACTION TIME	32-Monitor Digital	0.00		0.80	0.00
1300	Identify/Understand Situatio	0230	CHOICE REACTION TIME	19-Read/Analog	0.00		0.80	0.00
1301	Identify/Understand Situatio	0230	CHOICE REACTION TIME	20-Scan	0.00		0.80	0.00
1302	Identify/Understand Situatio	0230	CHOICE REACTION TIME	21-Update/ Analog	0.00		0.80	0.00
1303	Identify/Understand Situatio	0230	CHOICE REACTION TIME	22-Check Status	0.00		0.80	0.00
1304	Identify/Understand Situatio	0230	CHOICE REACTION TIME	23-Problem Definition	0.00		0.80	0.00
1305	Identify/Understand Situatio	0230	CHOICE REACTION TIME	24-Listen/Monitor - Analog	0.00		0.80	0.00
1306	Identify/Understand Situatio	0230	CHOICE REACTION TIME	30-Read/ Digital	0.00		0.80	0.00
1307	Identify/Understand Situatio	0230	CHOICE REACTION TIME	31-Scan Digital	0.00		0.80	0.00
1308	Identify/Understand Situatio	0230	CHOICE REACTION TIME	32-Monitor Digital	0.00		0.80	0.00
1309	Identify/Understand Situatio	0240	NEAR VISION	19-Read/Analog	1.22		0.80	0.98
1310	Identify/Understand Situatio	0240	NEAR VISION	20-Scan	1.22		0.80	0.98
1311	Identify/Understand Situatio	0240	NEAR VISION	21-Update/ Analog	1.22		0.80	0.98
1312	Identify/Understand Situatio	0240	NEAR VISION	22-Check Status	0.00		0.80	0.00
1313	Identify/Understand Situatio	0240	NEAR VISION	23-Problem Definition	0.00		0.80	0.00
1314	Identify/Understand Situatio	0240	NEAR VISION	24-Listen/Monitor - Analog	0.00		0.80	0.00
1315	Identify/Understand Situatio	0240	NEAR VISION	30-Read/ Digital	1.22		0.80	0.98
1316	Identify/Understand Situatio	0240	NEAR VISION	31-Scan Digital	1.22		0.80	0.98
1317	Identify/Understand Situatio	0240	NEAR VISION	32-Monitor Digital	1.22		0.80	0.98
1318	Identify/Understand Situatio	0250	FAR VISION	19-Read/Analog	0.00		0.80	0.00
1319	Identify/Understand Situatio	0250	FAR VISION	20-Scan	0.00		0.80	0.00
1320	Identify/Understand Situatio	0250	FAR VISION	21-Update/ Analog	0.00		0.80	0.00
1321	Identify/Understand Situatio	0250	FAR VISION	22-Check Status	1.08		0.80	0.86
1322	Identify/Understand Situatio	0250	FAR VISION	23-Problem Definition	0.00		0.80	0.00
1323	Identify/Understand Situatio	0250	FAR VISION	24-Listen/Monitor - Analog	0.00		0.80	0.00
1324	Identify/Understand Situatio	0250	FAR VISION	30-Read/ Digital	0.00		0.80	0.00
1325	Identify/Understand Situatio	0250	FAR VISION	31-Scan Digital	0.00		0.80	0.00
1326	Identify/Understand Situatio	0250	FAR VISION	32-Monitor Digital	0.00		0.80	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
1327	Identify/Understand Situatio	0260	NIGHT VISION	19-Read/Analog	0.00		0.80	0.00
1328	Identify/Understand Situatio	0260	NIGHT VISION	20-Scan	0.00		0.80	0.00
1329	Identify/Understand Situatio	0260	NIGHT VISION	21-Update/ Analog	0.00		0.80	0.00
1330	Identify/Understand Situatio	0260	NIGHT VISION	22-Check Status	0.00		0.80	0.00
1331	Identify/Understand Situatio	0260	NIGHT VISION	23-Problem Definition	0.00		0.80	0.00
1332	Identify/Understand Situatio	0260	NIGHT VISION	24-Listen/Monitor - Analog	0.00		0.80	0.00
1333	Identify/Understand Situatio	0260	NIGHT VISION	30-Read/ Digital	0.00		0.80	0.00
1334	Identify/Understand Situatio	0260	NIGHT VISION	31-Scan Digital	0.00		0.80	0.00
1335	Identify/Understand Situatio	0260	NIGHT VISION	32-Monitor Digital	0.00		0.80	0.00
1336	Identify/Understand Situatio	0270	VISUAL COLOR DISCRIMIN	19-Read/Analog	0.00		0.80	0.00
1337	Identify/Understand Situatio	0270	VISUAL COLOR DISCRIMIN	20-Scan	1.50		0.80	1.20
1338	Identify/Understand Situatio	0270	VISUAL COLOR DISCRIMIN	21-Update/ Analog	1.50		0.80	1.20
1339	Identify/Understand Situatio	0270	VISUAL COLOR DISCRIMIN	22-Check Status	1.50		0.80	1.20
1340	Identify/Understand Situatio	0270	VISUAL COLOR DISCRIMIN	23-Problem Definition	0.00		0.80	0.00
1341	Identify/Understand Situatio	0270	VISUAL COLOR DISCRIMIN	24-Listen/Monitor - Analog	0.00		0.80	0.00
1342	Identify/Understand Situatio	0270	VISUAL COLOR DISCRIMIN	30-Read/ Digital	1.50		0.80	1.20
1343	Identify/Understand Situatio	0270	VISUAL COLOR DISCRIMIN	31-Scan Digital	1.50		0.80	1.20
1344	Identify/Understand Situatio	0270	VISUAL COLOR DISCRIMIN	32-Monitor Digital	1.50		0.80	1.20
1345	Identify/Understand Situatio	0280	PERIPHERAL VISION	19-Read/Analog	0.00		0.80	0.00
1346	Identify/Understand Situatio	0280	PERIPHERAL VISION	20-Scan	0.00		0.80	0.00
1347	Identify/Understand Situatio	0280	PERIPHERAL VISION	21-Update/ Analog	0.00		0.80	0.00
1348	Identify/Understand Situatio	0280	PERIPHERAL VISION	22-Check Status	0.00		0.80	0.00
1349	Identify/Understand Situatio	0280	PERIPHERAL VISION	23-Problem Definition	0.00		0.80	0.00
1350	Identify/Understand Situatio	0280	PERIPHERAL VISION	24-Listen/Monitor - Analog	0.00		0.80	0.00
1351	Identify/Understand Situatio	0280	PERIPHERAL VISION	30-Read/ Digital	0.00		0.80	0.00
1352	Identify/Understand Situatio	0280	PERIPHERAL VISION	31-Scan Digital	0.00		0.80	0.00
1353	Identify/Understand Situatio	0280	PERIPHERAL VISION	32-Monitor Digital	0.00		0.80	0.00
1354	Identify/Understand Situatio	0290	DEPTH PERCEPTION	19-Read/Analog	0.00		0.80	0.00
1355	Identify/Understand Situatio	0290	DEPTH PERCEPTION	20-Scan	0.00		0.80	0.00
1356	Identify/Understand Situatio	0290	DEPTH PERCEPTION	21-Update/ Analog	0.00		0.80	0.00
1357	Identify/Understand Situatio	0290	DEPTH PERCEPTION	22-Check Status	1.00		0.80	0.80
1358	Identify/Understand Situatio	0290	DEPTH PERCEPTION	23-Problem Definition	0.00		0.80	0.00
1359	Identify/Understand Situatio	0290	DEPTH PERCEPTION	24-Listen/Monitor - Analog	0.00		0.80	0.00
1360	Identify/Understand Situatio	0290	DEPTH PERCEPTION	30-Read/ Digital	0.00		0.80	0.00
1361	Identify/Understand Situatio	0290	DEPTH PERCEPTION	31-Scan Digital	0.00		0.80	0.00
1362	Identify/Understand Situatio	0290	DEPTH PERCEPTION	32-Monitor Digital	0.00		0.80	0.00
1363	Identify/Understand Situatio	0300	GLARE SENSITIVITY	19-Read/Analog	0.00		0.80	0.00
1364	Identify/Understand Situatio	0300	GLARE SENSITIVITY	20-Scan	0.00		0.80	0.00
1365	Identify/Understand Situatio	0300	GLARE SENSITIVITY	21-Update/ Analog	0.00		0.80	0.00
1366	Identify/Understand Situatio	0300	GLARE SENSITIVITY	22-Check Status	0.00		0.80	0.00
1367	Identify/Understand Situatio	0300	GLARE SENSITIVITY	23-Problem Definition	0.00		0.80	0.00
1368	Identify/Understand Situatio	0300	GLARE SENSITIVITY	24-Listen/Monitor - Analog	0.00		0.80	0.00
1369	Identify/Understand Situatio	0300	GLARE SENSITIVITY	30-Read/ Digital	0.00		0.80	0.00
1370	Identify/Understand Situatio	0300	GLARE SENSITIVITY	31-Scan Digital	0.00		0.80	0.00
1371	Identify/Understand Situatio	0300	GLARE SENSITIVITY	32-Monitor Digital	0.00		0.80	0.00
1372	Identify/Understand Situatio	0310	GENERAL HEARING	19-Read/Analog	0.00		0.80	0.00
1373	Identify/Understand Situatio	0310	GENERAL HEARING	20-Scan	0.00		0.80	0.00
1374	Identify/Understand Situatio	0310	GENERAL HEARING	21-Update/ Analog	0.00		0.80	0.00
1375	Identify/Understand Situatio	0310	GENERAL HEARING	22-Check Status	0.00		0.80	0.00
1376	Identify/Understand Situatio	0310	GENERAL HEARING	23-Problem Definition	0.00		0.80	0.00
1377	Identify/Understand Situatio	0310	GENERAL HEARING	24-Listen/Monitor - Analog	0.00		0.80	0.00
1378	Identify/Understand Situatio	0310	GENERAL HEARING	30-Read/ Digital	0.00		0.80	0.00
1379	Identify/Understand Situatio	0310	GENERAL HEARING	31-Scan Digital	0.00		0.80	0.00

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	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
1380	Identify/Understand Situatio	0310	GENERAL HEARING	32-Monitor Digital	0.00		0.80	0.00
1381	Identify/Understand Situatio	0320	AUDITORY ATTENTION	19-Read/Analog	0.00		0.80	0.00
1382	Identify/Understand Situatio	0320	AUDITORY ATTENTION	20-Scan	0.00		0.80	0.00
1383	Identify/Understand Situatio	0320	AUDITORY ATTENTION	21-Update/ Analog	0.00		0.80	0.00
1384	Identify/Understand Situatio	0320	AUDITORY ATTENTION	22-Check Status	0.00		0.80	0.00
1385	Identify/Understand Situatio	0320	AUDITORY ATTENTION	23-Problem Definition	1.96		0.80	1.57
1386	Identify/Understand Situatio	0320	AUDITORY ATTENTION	24-Listen/Monitor - Analog	1.96		0.80	1.57
1387	Identify/Understand Situatio	0320	AUDITORY ATTENTION	30-Read/ Digital	0.00		0.80	0.00
1388	Identify/Understand Situatio	0320	AUDITORY ATTENTION	31-Scan Digital	0.00		0.80	0.00
1389	Identify/Understand Situatio	0320	AUDITORY ATTENTION	32-Monitor Digital	0.00		0.80	0.00
1390	Identify/Understand Situatio	0330	SOUND LOCALIZATION	19-Read/Analog	0.00		0.80	0.00
1391	Identify/Understand Situatio	0330	SOUND LOCALIZATION	20-Scan	0.00		0.80	0.00
1392	Identify/Understand Situatio	0330	SOUND LOCALIZATION	21-Update/ Analog	0.00		0.80	0.00
1393	Identify/Understand Situatio	0330	SOUND LOCALIZATION	22-Check Status	0.00		0.80	0.00
1394	Identify/Understand Situatio	0330	SOUND LOCALIZATION	23-Problem Definition	0.00		0.80	0.00
1395	Identify/Understand Situatio	0330	SOUND LOCALIZATION	24-Listen/Monitor - Analog	0.00		0.80	0.00
1396	Identify/Understand Situatio	0330	SOUND LOCALIZATION	30-Read/ Digital	0.00		0.80	0.00
1397	Identify/Understand Situatio	0330	SOUND LOCALIZATION	31-Scan Digital	0.00		0.80	0.00
1398	Identify/Understand Situatio	0330	SOUND LOCALIZATION	32-Monitor Digital	0.00		0.80	0.00
1399	Identify/Understand Situatio	0340	CONTROL PRECISION	19-Read/Analog	0.00		0.80	0.00
1400	Identify/Understand Situatio	0340	CONTROL PRECISION	20-Scan	0.00		0.80	0.00
1401	Identify/Understand Situatio	0340	CONTROL PRECISION	21-Update/ Analog	0.00		0.80	0.00
1402	Identify/Understand Situatio	0340	CONTROL PRECISION	22-Check Status	0.00		0.80	0.00
1403	Identify/Understand Situatio	0340	CONTROL PRECISION	23-Problem Definition	0.00		0.80	0.00
1404	Identify/Understand Situatio	0340	CONTROL PRECISION	24-Listen/Monitor - Analog	0.00		0.80	0.00
1405	Identify/Understand Situatio	0340	CONTROL PRECISION	30-Read/ Digital	0.00		0.80	0.00
1406	Identify/Understand Situatio	0340	CONTROL PRECISION	31-Scan Digital	0.00		0.80	0.00
1407	Identify/Understand Situatio	0340	CONTROL PRECISION	32-Monitor Digital	0.00		0.80	0.00
1408	Identify/Understand Situatio	0350	RATE CONTROL	19-Read/Analog	0.00		0.80	0.00
1409	Identify/Understand Situatio	0350	RATE CONTROL	20-Scan	0.00		0.80	0.00
1410	Identify/Understand Situatio	0350	RATE CONTROL	21-Update/ Analog	0.00		0.80	0.00
1411	Identify/Understand Situatio	0350	RATE CONTROL	22-Check Status	0.00		0.80	0.00
1412	Identify/Understand Situatio	0350	RATE CONTROL	23-Problem Definition	0.00		0.80	0.00
1413	Identify/Understand Situatio	0350	RATE CONTROL	24-Listen/Monitor - Analog	0.00		0.80	0.00
1414	Identify/Understand Situatio	0350	RATE CONTROL	30-Read/ Digital	0.00		0.80	0.00
1415	Identify/Understand Situatio	0350	RATE CONTROL	31-Scan Digital	0.00		0.80	0.00
1416	Identify/Understand Situatio	0350	RATE CONTROL	32-Monitor Digital	0.00		0.80	0.00
1417	Identify/Understand Situatio	0360	WRIST-FINGER SPEED	19-Read/Analog	0.00		0.80	0.00
1418	Identify/Understand Situatio	0360	WRIST-FINGER SPEED	20-Scan	0.00		0.80	0.00
1419	Identify/Understand Situatio	0360	WRIST-FINGER SPEED	21-Update/ Analog	0.00		0.80	0.00
1420	Identify/Understand Situatio	0360	WRIST-FINGER SPEED	22-Check Status	0.00		0.80	0.00
1421	Identify/Understand Situatio	0360	WRIST-FINGER SPEED	23-Problem Definition	0.00		0.80	0.00
1422	Identify/Understand Situatio	0360	WRIST-FINGER SPEED	24-Listen/Monitor - Analog	0.00		0.80	0.00
1423	Identify/Understand Situatio	0360	WRIST-FINGER SPEED	30-Read/ Digital	1.00		0.80	0.80
1424	Identify/Understand Situatio	0360	WRIST-FINGER SPEED	31-Scan Digital	1.00		0.80	0.80
1425	Identify/Understand Situatio	0360	WRIST-FINGER SPEED	32-Monitor Digital	0.00		0.80	0.00
1426	Identify/Understand Situatio	0370	FINGER DEXTERITY	19-Read/Analog	0.00		0.80	0.00
1427	Identify/Understand Situatio	0370	FINGER DEXTERITY	20-Scan	0.00		0.80	0.00
1428	Identify/Understand Situatio	0370	FINGER DEXTERITY	21-Update/ Analog	1.03		0.80	0.82
1429	Identify/Understand Situatio	0370	FINGER DEXTERITY	22-Check Status	0.00		0.80	0.00
1430	Identify/Understand Situatio	0370	FINGER DEXTERITY	23-Problem Definition	0.00		0.80	0.00
1431	Identify/Understand Situatio	0370	FINGER DEXTERITY	24-Listen/Monitor - Analog	0.00		0.80	0.00
1432	Identify/Understand Situatio	0370	FINGER DEXTERITY	30-Read/ Digital	1.03		0.80	0.82

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
1433	Identify/Understand Situatio	0370	FINGER DEXTERITY	31-Scan Digital	1.03		0.80	0.82
1434	Identify/Understand Situatio	0370	FINGER DEXTERITY	32-Monitor Digital	0.00		0.80	0.00
1435	Identify/Understand Situatio	0380	MANUAL DEXTERITY	19-Read/Analog	0.00		0.80	0.00
1436	Identify/Understand Situatio	0380	MANUAL DEXTERITY	20-Scan	0.00		0.80	0.00
1437	Identify/Understand Situatio	0380	MANUAL DEXTERITY	21-Update/ Analog	1.21		0.80	0.97
1438	Identify/Understand Situatio	0380	MANUAL DEXTERITY	22-Check Status	0.00		0.80	0.00
1439	Identify/Understand Situatio	0380	MANUAL DEXTERITY	23-Problem Definition	0.00		0.80	0.00
1440	Identify/Understand Situatio	0380	MANUAL DEXTERITY	24-Listen/Monitor - Analog	0.00		0.80	0.00
1441	Identify/Understand Situatio	0380	MANUAL DEXTERITY	30-Read/ Digital	1.21		0.80	0.97
1442	Identify/Understand Situatio	0380	MANUAL DEXTERITY	31-Scan Digital	1.21		0.80	0.97
1443	Identify/Understand Situatio	0380	MANUAL DEXTERITY	32-Monitor Digital	0.00		0.80	0.00
1444	Identify/Understand Situatio	0390	ARM-HAND STEADINESS	19-Read/Analog	0.00		0.80	0.00
1445	Identify/Understand Situatio	0390	ARM-HAND STEADINESS	20-Scan	0.00		0.80	0.00
1446	Identify/Understand Situatio	0390	ARM-HAND STEADINESS	21-Update/ Analog	0.00		0.80	0.00
1447	Identify/Understand Situatio	0390	ARM-HAND STEADINESS	22-Check Status	0.00		0.80	0.00
1448	Identify/Understand Situatio	0390	ARM-HAND STEADINESS	23-Problem Definition	0.00		0.80	0.00
1449	Identify/Understand Situatio	0390	ARM-HAND STEADINESS	24-Listen/Monitor - Analog	0.00		0.80	0.00
1450	Identify/Understand Situatio	0390	ARM-HAND STEADINESS	30-Read/ Digital	0.00		0.80	0.00
1451	Identify/Understand Situatio	0390	ARM-HAND STEADINESS	31-Scan Digital	0.00		0.80	0.00
1452	Identify/Understand Situatio	0390	ARM-HAND STEADINESS	32-Monitor Digital	0.00		0.80	0.00
1453	Identify/Understand Situatio	0400	MULTI-LIMB COORDINATIC	19-Read/Analog	0.00		0.80	0.00
1454	Identify/Understand Situatio	0400	MULTI-LIMB COORDINATIC	20-Scan	0.00		0.80	0.00
1455	Identify/Understand Situatio	0400	MULTI-LIMB COORDINATIC	21-Update/ Analog	0.00		0.80	0.00
1456	Identify/Understand Situatio	0400	MULTI-LIMB COORDINATIC	22-Check Status	0.00		0.80	0.00
1457	Identify/Understand Situatio	0400	MULTI-LIMB COORDINATIC	23-Problem Definition	0.00		0.80	0.00
1458	Identify/Understand Situatio	0400	MULTI-LIMB COORDINATIC	24-Listen/Monitor - Analog	0.00		0.80	0.00
1459	Identify/Understand Situatio	0400	MULTI-LIMB COORDINATIC	30-Read/ Digital	0.00		0.80	0.00
1460	Identify/Understand Situatio	0400	MULTI-LIMB COORDINATIC	31-Scan Digital	0.00		0.80	0.00
1461	Identify/Understand Situatio	0400	MULTI-LIMB COORDINATIC	32-Monitor Digital	0.00		0.80	0.00
1462	Identify/Understand Situatio	0410	EXTENT FLEXIBILITY	19-Read/Analog	0.00		0.80	0.00
1463	Identify/Understand Situatio	0410	EXTENT FLEXIBILITY	20-Scan	0.00		0.80	0.00
1464	Identify/Understand Situatio	0410	EXTENT FLEXIBILITY	21-Update/ Analog	0.00		0.80	0.00
1465	Identify/Understand Situatio	0410	EXTENT FLEXIBILITY	22-Check Status	0.00		0.80	0.00
1466	Identify/Understand Situatio	0410	EXTENT FLEXIBILITY	23-Problem Definition	0.00		0.80	0.00
1467	Identify/Understand Situatio	0410	EXTENT FLEXIBILITY	24-Listen/Monitor - Analog	0.00		0.80	0.00
1468	Identify/Understand Situatio	0410	EXTENT FLEXIBILITY	30-Read/ Digital	0.00		0.80	0.00
1469	Identify/Understand Situatio	0410	EXTENT FLEXIBILITY	31-Scan Digital	0.00		0.80	0.00
1470	Identify/Understand Situatio	0410	EXTENT FLEXIBILITY	32-Monitor Digital	0.00		0.80	0.00
1471	Identify/Understand Situatio	0420	DYNAMIC FLEXIBILITY	19-Read/Analog	0.00		0.80	0.00
1472	Identify/Understand Situatio	0420	DYNAMIC FLEXIBILITY	20-Scan	0.00		0.80	0.00
1473	Identify/Understand Situatio	0420	DYNAMIC FLEXIBILITY	21-Update/ Analog	0.00		0.80	0.00
1474	Identify/Understand Situatio	0420	DYNAMIC FLEXIBILITY	22-Check Status	0.00		0.80	0.00
1475	Identify/Understand Situatio	0420	DYNAMIC FLEXIBILITY	23-Problem Definition	0.00		0.80	0.00
1476	Identify/Understand Situatio	0420	DYNAMIC FLEXIBILITY	24-Listen/Monitor - Analog	0.00		0.80	0.00
1477	Identify/Understand Situatio	0420	DYNAMIC FLEXIBILITY	30-Read/ Digital	0.00		0.80	0.00
1478	Identify/Understand Situatio	0420	DYNAMIC FLEXIBILITY	31-Scan Digital	0.00		0.80	0.00
1479	Identify/Understand Situatio	0420	DYNAMIC FLEXIBILITY	32-Monitor Digital	0.00		0.80	0.00
1480	Identify/Understand Situatio	0430	SPEED OF LIMB MOVEMEI	19-Read/Analog	0.00		0.80	0.00
1481	Identify/Understand Situatio	0430	SPEED OF LIMB MOVEMEI	20-Scan	0.00		0.80	0.00
1482	Identify/Understand Situatio	0430	SPEED OF LIMB MOVEMEI	21-Update/ Analog	0.00		0.80	0.00
1483	Identify/Understand Situatio	0430	SPEED OF LIMB MOVEMEI	22-Check Status	0.00		0.80	0.00
1484	Identify/Understand Situatio	0430	SPEED OF LIMB MOVEMEI	23-Problem Definition	0.00		0.80	0.00
1485	Identify/Understand Situatio	0430	SPEED OF LIMB MOVEMEI	24-Listen/Monitor - Analog	0.00		0.80	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
1486	Identify/Understand Situatio	0430	SPEED OF LIMB MOVEMEI	30-Read/ Digital	0.00		0.80	0.00
1487	Identify/Understand Situatio	0430	SPEED OF LIMB MOVEMEI	31-Scan Digital	0.00		0.80	0.00
1488	Identify/Understand Situatio	0430	SPEED OF LIMB MOVEMEI	32-Monitor Digital	0.00		0.80	0.00
1489	Identify/Understand Situatio	0440	GROSS BODY EQUILIBRIU	19-Read/Analog	0.00		0.80	0.00
1490	Identify/Understand Situatio	0440	GROSS BODY EQUILIBRIU	20-Scan	0.00		0.80	0.00
1491	Identify/Understand Situatio	0440	GROSS BODY EQUILIBRIU	21-Update/ Analog	0.00		0.80	0.00
1492	Identify/Understand Situatio	0440	GROSS BODY EQUILIBRIU	22-Check Status	0.00		0.80	0.00
1493	Identify/Understand Situatio	0440	GROSS BODY EQUILIBRIU	23-Problem Definition	0.00		0.80	0.00
1494	Identify/Understand Situatio	0440	GROSS BODY EQUILIBRIU	24-Listen/Monitor - Analog	0.00		0.80	0.00
1495	Identify/Understand Situatio	0440	GROSS BODY EQUILIBRIU	30-Read/ Digital	0.00		0.80	0.00
1496	Identify/Understand Situatio	0440	GROSS BODY EQUILIBRIU	31-Scan Digital	0.00		0.80	0.00
1497	Identify/Understand Situatio	0440	GROSS BODY EQUILIBRIU	32-Monitor Digital	0.00		0.80	0.00
1498	Identify/Understand Situatio	0450	GROSS BODY COORDINA	19-Read/Analog	0.00		0.80	0.00
1499	Identify/Understand Situatio	0450	GROSS BODY COORDINA	20-Scan	0.00		0.80	0.00
1500	Identify/Understand Situatio	0450	GROSS BODY COORDINA	21-Update/ Analog	0.00		0.80	0.00
1501	Identify/Understand Situatio	0450	GROSS BODY COORDINA	22-Check Status	1.02		0.80	0.82
1502	Identify/Understand Situatio	0450	GROSS BODY COORDINA	23-Problem Definition	0.00		0.80	0.00
1503	Identify/Understand Situatio	0450	GROSS BODY COORDINA	24-Listen/Monitor - Analog	0.00		0.80	0.00
1504	Identify/Understand Situatio	0450	GROSS BODY COORDINA	30-Read/ Digital	0.00		0.80	0.00
1505	Identify/Understand Situatio	0450	GROSS BODY COORDINA	31-Scan Digital	0.00		0.80	0.00
1506	Identify/Understand Situatio	0450	GROSS BODY COORDINA	32-Monitor Digital	0.00		0.80	0.00
1507	Identify/Understand Situatio	0460	STATIC STRENGTH	19-Read/Analog	0.00		0.80	0.00
1508	Identify/Understand Situatio	0460	STATIC STRENGTH	20-Scan	0.00		0.80	0.00
1509	Identify/Understand Situatio	0460	STATIC STRENGTH	21-Update/ Analog	0.00		0.80	0.00
1510	Identify/Understand Situatio	0460	STATIC STRENGTH	22-Check Status	0.00		0.80	0.00
1511	Identify/Understand Situatio	0460	STATIC STRENGTH	23-Problem Definition	0.00		0.80	0.00
1512	Identify/Understand Situatio	0460	STATIC STRENGTH	24-Listen/Monitor - Analog	0.00		0.80	0.00
1513	Identify/Understand Situatio	0460	STATIC STRENGTH	30-Read/ Digital	0.00		0.80	0.00
1514	Identify/Understand Situatio	0460	STATIC STRENGTH	31-Scan Digital	0.00		0.80	0.00
1515	Identify/Understand Situatio	0460	STATIC STRENGTH	32-Monitor Digital	0.00		0.80	0.00
1516	Identify/Understand Situatio	0470	EXPLOSIVE STRENGTH	19-Read/Analog	0.00		0.80	0.00
1517	Identify/Understand Situatio	0470	EXPLOSIVE STRENGTH	20-Scan	0.00		0.80	0.00
1518	Identify/Understand Situatio	0470	EXPLOSIVE STRENGTH	21-Update/ Analog	0.00		0.80	0.00
1519	Identify/Understand Situatio	0470	EXPLOSIVE STRENGTH	22-Check Status	0.00		0.80	0.00
1520	Identify/Understand Situatio	0470	EXPLOSIVE STRENGTH	23-Problem Definition	0.00		0.80	0.00
1521	Identify/Understand Situatio	0470	EXPLOSIVE STRENGTH	24-Listen/Monitor - Analog	0.00		0.80	0.00
1522	Identify/Understand Situatio	0470	EXPLOSIVE STRENGTH	30-Read/ Digital	0.00		0.80	0.00
1523	Identify/Understand Situatio	0470	EXPLOSIVE STRENGTH	31-Scan Digital	0.00		0.80	0.00
1524	Identify/Understand Situatio	0470	EXPLOSIVE STRENGTH	32-Monitor Digital	0.00		0.80	0.00
1525	Identify/Understand Situatio	0480	DYNAMIC STRENGTH	19-Read/Analog	0.00		0.80	0.00
1526	Identify/Understand Situatio	0480	DYNAMIC STRENGTH	20-Scan	0.00		0.80	0.00
1527	Identify/Understand Situatio	0480	DYNAMIC STRENGTH	21-Update/ Analog	0.00		0.80	0.00
1528	Identify/Understand Situatio	0480	DYNAMIC STRENGTH	22-Check Status	0.00		0.80	0.00
1529	Identify/Understand Situatio	0480	DYNAMIC STRENGTH	23-Problem Definition	0.00		0.80	0.00
1530	Identify/Understand Situatio	0480	DYNAMIC STRENGTH	24-Listen/Monitor - Analog	0.00		0.80	0.00
1531	Identify/Understand Situatio	0480	DYNAMIC STRENGTH	30-Read/ Digital	0.00		0.80	0.00
1532	Identify/Understand Situatio	0480	DYNAMIC STRENGTH	31-Scan Digital	0.00		0.80	0.00
1533	Identify/Understand Situatio	0480	DYNAMIC STRENGTH	32-Monitor Digital	0.00		0.80	0.00
1534	Identify/Understand Situatio	0490	TRUNK STRENGTH	19-Read/Analog	0.00		0.80	0.00
1535	Identify/Understand Situatio	0490	TRUNK STRENGTH	20-Scan	0.00		0.80	0.00
1536	Identify/Understand Situatio	0490	TRUNK STRENGTH	21-Update/ Analog	0.00		0.80	0.00
1537	Identify/Understand Situatio	0490	TRUNK STRENGTH	22-Check Status	0.00		0.80	0.00
1538	Identify/Understand Situatio	0490	TRUNK STRENGTH	23-Problem Definition	0.00		0.80	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
1539	Identify/Understand Situatio	0490	TRUNK STRENGTH	24-Listen/Monitor - Analog	0.00		0.80	0.00
1540	Identify/Understand Situatio	0490	TRUNK STRENGTH	30-Read/ Digital	0.00		0.80	0.00
1541	Identify/Understand Situatio	0490	TRUNK STRENGTH	31-Scan Digital	0.00		0.80	0.00
1542	Identify/Understand Situatio	0490	TRUNK STRENGTH	32-Monitor Digital	0.00		0.80	0.00
1543	Identify/Understand Situatio	0500	STAMINA	19-Read/Analog	0.00		0.80	0.00
1544	Identify/Understand Situatio	0500	STAMINA	20-Scan	0.00		0.80	0.00
1545	Identify/Understand Situatio	0500	STAMINA	21-Update/ Analog	0.00		0.80	0.00
1546	Identify/Understand Situatio	0500	STAMINA	22-Check Status	0.00		0.80	0.00
1547	Identify/Understand Situatio	0500	STAMINA	23-Problem Definition	0.00		0.80	0.00
1548	Identify/Understand Situatio	0500	STAMINA	24-Listen/Monitor - Analog	0.00		0.80	0.00
1549	Identify/Understand Situatio	0500	STAMINA	30-Read/ Digital	0.00		0.80	0.00
1550	Identify/Understand Situatio	0500	STAMINA	31-Scan Digital	0.00		0.80	0.00
1551	Identify/Understand Situatio	0500	STAMINA	32-Monitor Digital	0.00		0.80	0.00
1552	Manage Resources	0010	ORAL COMPREHENSION	25-Manage Resources	0.00		0.80	0.00
1553	Manage Resources	0020	WRITTEN COMPREHENSI	25-Manage Resources	0.00		0.80	0.00
1554	Manage Resources	0030	ORAL EXPRESSION	25-Manage Resources	0.00		0.80	0.00
1555	Manage Resources	0040	WRITTEN EXPRESSION	25-Manage Resources	0.00		0.80	0.00
1556	Manage Resources	0050	MEMORIZATION	25-Manage Resources	0.00		0.80	0.00
1557	Manage Resources	0060	PROBLEM SENSITIVITY	25-Manage Resources	0.00		0.80	0.00
1558	Manage Resources	0070	ORIGINALITY	25-Manage Resources	0.00		0.80	0.00
1559	Manage Resources	0080	FLUENCY OF IDEAS	25-Manage Resources	0.00		0.80	0.00
1560	Manage Resources	0090	FLEXIBILITY OF CLOSURE	25-Manage Resources	0.00		0.80	0.00
1561	Manage Resources	0100	SELECTIVE ATTENTION	25-Manage Resources	0.00		0.80	0.00
1562	Manage Resources	0110	SPATIAL ORIENTATION	25-Manage Resources	0.00		0.80	0.00
1563	Manage Resources	0120	VISUALIZATION	25-Manage Resources	0.00		0.80	0.00
1564	Manage Resources	0130	INDUCTIVE REASONING	25-Manage Resources	0.00		0.80	0.00
1565	Manage Resources	0140	CATEGORY FLEXIBILITY	25-Manage Resources	0.00		0.80	0.00
1566	Manage Resources	0150	DEDUCTIVE REASONING	25-Manage Resources	0.00		0.80	0.00
1567	Manage Resources	0160	INFORMATION ORDERING	25-Manage Resources	0.00		0.80	0.00
1568	Manage Resources	0170	MATHEMATICAL REASONI	25-Manage Resources	0.00		0.80	0.00
1569	Manage Resources	0180	NUMBER FACILITY	25-Manage Resources	0.00		0.80	0.00
1570	Manage Resources	0190	TIME SHARING	25-Manage Resources	0.00		0.80	0.00
1571	Manage Resources	0200	SPEED OF CLOSURE	25-Manage Resources	0.00		0.80	0.00
1572	Manage Resources	0210	PERCEPTUAL SPEED AND	25-Manage Resources	0.00		0.80	0.00
1573	Manage Resources	0220	REACTION TIME	25-Manage Resources	0.00		0.80	0.00
1574	Manage Resources	0230	CHOICE REACTION TIME	25-Manage Resources	0.00		0.80	0.00
1575	Manage Resources	0240	NEAR VISION	25-Manage Resources	0.00		0.80	0.00
1576	Manage Resources	0250	FAR VISION	25-Manage Resources	0.00		0.80	0.00
1577	Manage Resources	0260	NIGHT VISION	25-Manage Resources	0.00		0.80	0.00
1578	Manage Resources	0270	VISUAL COLOR DISCRIMIN	25-Manage Resources	0.00		0.80	0.00
1579	Manage Resources	0280	PERIPHERAL VISION	25-Manage Resources	0.00		0.80	0.00
1580	Manage Resources	0290	DEPTH PERCEPTION	25-Manage Resources	0.00		0.80	0.00
1581	Manage Resources	0300	GLARE SENSITIVITY	25-Manage Resources	0.00		0.80	0.00
1582	Manage Resources	0310	GENERAL HEARING	25-Manage Resources	0.00		0.80	0.00
1583	Manage Resources	0320	AUDITORY ATTENTION	25-Manage Resources	0.00		0.80	0.00
1584	Manage Resources	0330	SOUND LOCALIZATION	25-Manage Resources	0.00		0.80	0.00
1585	Manage Resources	0340	CONTROL PRECISION	25-Manage Resources	0.00		0.80	0.00
1586	Manage Resources	0350	RATE CONTROL	25-Manage Resources	0.00		0.80	0.00
1587	Manage Resources	0360	WRIST-FINGER SPEED	25-Manage Resources	0.00		0.80	0.00
1588	Manage Resources	0370	FINGER DEXTERITY	25-Manage Resources	0.00		0.80	0.00
1589	Manage Resources	0380	MANUAL DEXTERITY	25-Manage Resources	0.00		0.80	0.00
1590	Manage Resources	0390	ARM-HAND STEADINESS	25-Manage Resources	0.00		0.80	0.00
1591	Manage Resources	0400	MULTI-LIMB COORDINATI	25-Manage Resources	0.00		0.80	0.00

Appendix B: KSA Data Configuration for Treatment Condition #1: PMMMM

	B	C	D	E	F	G	H	I
1	DutyName	Scale Number	ScaleName	DetailDuty	Detail Score		Treatment Factor	Detail Score-Adj
1592	Manage Resources	0410	EXTENT FLEXIBILITY	25-Manage Resources	0.00		0.80	0.00
1593	Manage Resources	0420	DYNAMIC FLEXIBILITY	25-Manage Resources	0.00		0.80	0.00
1594	Manage Resources	0430	SPEED OF LIMB MOVEMEI	25-Manage Resources	0.00		0.80	0.00
1595	Manage Resources	0440	GROSS BODY EQUILIBRIU	25-Manage Resources	0.00		0.80	0.00
1596	Manage Resources	0450	GROSS BODY COORDINA	25-Manage Resources	0.00		0.80	0.00
1597	Manage Resources	0460	STATIC STRENGTH	25-Manage Resources	0.00		0.80	0.00
1598	Manage Resources	0470	EXPLOSIVE STRENGTH	25-Manage Resources	0.00		0.80	0.00
1599	Manage Resources	0480	DYNAMIC STRENGTH	25-Manage Resources	0.00		0.80	0.00
1600	Manage Resources	0490	TRUNK STRENGTH	25-Manage Resources	0.00		0.80	0.00
1601	Manage Resources	0500	STAMINA	25-Manage Resources	0.00		0.80	0.00
1602								
1603	Communicate and Report							
1604	Decide and Recommend / Direct							
1605	Evaluate and Estimate Impact							
1606	Identify/Understand Situational Picture							
1607	Manage Resources							

Appendix C – Task Time Treatment Condition 1 Setup Table.

802	Receive and Record	29		1	A	0.50	2	0.42	1- CAR	1.2	0.50	0.50	1
825	Receive and Record	29		1	A	0.50	2	0.42	1- CAR	1.2	0.50	0.50	2
817	Pass Info	29		2	A	2.02	2	1.68	1- CAR	1.2	2.02	2.02	3
863	Pass Info	29		2	A	19.66	2	16.38	1- CAR	1.2	19.66	19.66	4
824	Listen Receive	29		3	A	2.02	2	1.68	1- CAR	1.2	2.02	2.02	5
1108	Listen Receive	29		3	A	20.16	2	16.8	1- CAR	1.2	20.16	20.16	6
1704	Listen Receive	29		3	C	20.16	2	16.8	1- CAR	1.2	20.16	20.16	7
814	Secondary Monitor	29		4	A	0.00	0		1- CAR	1.2	0.00	0.00	8
811	Send Msg	29		7	A	26.12	2	21.77	1- CAR	1.2	26.12	26.12	9
877	Send Radio	29		7	A	26.12	2	21.77	1- CAR	1.2	26.12	26.12	10
871	Receive Digital Msg	29		26	A	1.82	2	1.52	1- CAR	1.2	1.82	1.82	11
884	Receive Digital - low priority	29		26	A	1.82	2	1.52	1- CAR	1.2	1.82	1.82	12
873	Pull Up Msg	29		27	A	45.90	1	38.25	1- CAR	1.2	45.90	45.90	13
878	Get Out of Msg	29		27	A	3.41	2	2.84	1- CAR	1.2	3.41	3.41	14
880	Fix Unformatted	29		27	A	22.08	1	18.4	1- CAR	1.2	22.08	22.08	15
881	Send Overlay	29		27	A	70.10	2	58.42	1- CAR	1.2	70.10	70.10	16
882	Compose Digital Msg	29		27	A	52.03	1	43.36	1- CAR	1.2	52.03	52.03	17
883	Send Digital	29		28	A	4.34	2	3.62	1- CAR	1.2	4.34	4.34	18
806	Decide Action	29		11	C	0.22	1	0.28	2- DRD	0.8	0.22	0.22	19
809	Decide Action	29		11	C	0.06	1	0.07	2- DRD	0.8	0.06	0.06	20
813	Decide Action	29		11	C	12.24	1	15.3	2- DRD	0.8	12.24	12.24	21
808	Estimate Impact	29		14	D	154.69	1	193.36	3- EEI	0.8	154.69	154.69	22
879	Estimate Msg Impact	29		14	D	2.55	1	3.19	3- EEI	0.8	2.55	2.55	23
819	Discuss	29		18	A	12.80	2	16	3- EEI	0.8	12.80	12.80	24
865	Discuss	29		18	A	12.00	2	15	3- EEI	0.8	12.00	12.00	25
1110	Discuss	29		18	A	55.33	2	69.16	3- EEI	0.8	55.33	55.33	26
1705	Discuss	29		18	C	56.67	2	70.84	3- EEI	0.8	56.67	56.67	27
804	Scan Board	29		20	B	13.26	1	16.58	4- ISP	0.8	13.26	13.26	28
805	Scan Map	29		20	B	3.22	1	4.02	4- ISP	0.8	3.22	3.22	29
810	Update	29		21	B	14.69	1	18.36	4- ISP	0.8	14.69	14.69	30
812	Check Status	29		22	B	75.64	1	94.55	4- ISP	0.8	75.64	75.64	31
875	Read Digital Msg	29		30	B	47.86	1	59.82	4- ISP	0.8	47.86	47.86	32
876	Scan Digital	29		31	A	1.47	1	1.84	4- ISP	0.8	1.47	1.47	33
872	Monitor Digital	29		32	A	0.00	1		4- ISP	0.8	0.00	0.00	34
801	Interrupt	29											35
822	Interrupt	29											36
861	CDR Begin	29					2						37
874	Interrupt	29				100		100					38
885	Icon Mvt/Color Chg	29											39
1103	Interrupt CMD	29				100000		100000					40
1701	Interrupt CMD	29				100000		100000					41

Appendix D – Data From Simulation Runs.

Data From Fractional Factorial- KSA Runs.

Random # Seed = 1.0 T1-KSA-PMMMM			
Battalion Commander	#	Adj #	Taskload (Workload) (Util)
Replication	1	1	31.99
Replication	2	2	31.88
Replication	3	3	31.95
Replication	4	4	31.88
Replication	5	5	31.68
Replication	6	x	
Replication	7	x	
Replication	8	x	
Replication	9	6	31.92
Replication	10	7	31.99
Replication	11	8	31.92
Replication	12	9	31.96
Replication	13	10	31.77
Replication	14	11	31.81
Replication	15	12	31.84
Replication	16	13	31.80
Replication	17	x	
Replication	18	14	31.88
Replication	19	15	32.00
Replication	20	n	
Average	15		31.88

Random # Seed = 1.0 T2-KSA-MPPMM			
Battalion Commander	#	Adj #	Workload (Util)
Replication	1	1	32.84
Replication	2	2	32.66
Replication	3	3	32.76
Replication	4	4	32.62
Replication	5	5	32.40
Replication	6	x	
Replication	7	x	
Replication	8	x	
Replication	9	6	32.67
Replication	10	7	32.79
Replication	11	8	32.65
Replication	12	9	32.73
Replication	13	10	32.40
Replication	14	11	32.48
Replication	15	12	32.59
Replication	16	13	32.42
Replication	17	x	
Replication	18	14	32.60
Replication	19	15	32.75
Replication	20	n	
Average	15		32.62

Random # Seed = 1.0 T3-KSA-PPMPM			
Battalion Commander	#	Adj #	Workload (Util)
Replication	1	1	46.30
Replication	2	2	46.22
Replication	3	3	46.29
Replication	4	4	46.25
Replication	5	5	45.97
Replication	6	x	
Replication	7	x	
Replication	8	x	
Replication	9	6	46.31
Replication	10	7	46.36
Replication	11	8	46.31
Replication	12	9	46.33
Replication	13	10	46.18
Replication	14	11	46.21
Replication	15	12	46.20
Replication	16	13	46.24
Replication	17	x	
Replication	18	14	46.29
Replication	19	15	46.42
Replication	20	n	
Average	15		46.26

Random # Seed = 1.0 T4-KSA-MMPPM			
Battalion Commander	#	Adj #	Workload (Util)
Replication	1	1	47.15
Replication	2	2	46.99
Replication	3	3	47.09
Replication	4	4	46.98
Replication	5	5	46.68
Replication	6	x	
Replication	7	x	
Replication	8	x	
Replication	9	6	47.05
Replication	10	7	47.15
Replication	11	8	47.03
Replication	12	9	47.09
Replication	13	10	46.80
Replication	14	11	46.87
Replication	15	12	46.94
Replication	16	13	46.85
Replication	17	x	
Replication	18	14	47.00
Replication	19	15	47.17
Replication	20	n	
Average	15		46.99

Random # Seed = 1.0

T5-KSA-MPMMP

Battalion Commander	#	Adj #	Workload (Util)
Replication	1	1	31.66
Replication	2	2	31.56
Replication	3	3	31.62
Replication	4	4	31.55
Replication	5	5	31.35
Replication	6	x	
Replication	7	x	
Replication	8	x	
Replication	9	6	31.60
Replication	10	7	31.66
Replication	11	8	31.59
Replication	12	9	31.63
Replication	13	10	31.44
Replication	14	11	31.48
Replication	15	12	31.52
Replication	16	13	31.47
Replication	17	x	
Replication	18	14	31.56
Replication	19	15	31.67
Replication	20	n	
Average	15		31.56

Random # Seed = 1.0

T6-KSA-PMPMP

Battalion Commander	#	Adj #	Workload (Util)
Replication	1	1	33.17
Replication	2	2	32.98
Replication	3	3	33.08
Replication	4	4	32.95
Replication	5	5	32.73
Replication	6	x	
Replication	7	x	
Replication	8	x	
Replication	9	6	33.00
Replication	10	7	33.12
Replication	11	8	32.98
Replication	12	9	33.05
Replication	13	10	32.73
Replication	14	11	32.81
Replication	15	12	32.92
Replication	16	13	32.76
Replication	17	x	
Replication	18	14	32.92
Replication	19	15	33.07
Replication	20	n	
Average	15		32.95

Random # Seed = 1.0

T7-KSA-MMMPP

Battalion Commander	#	Adj #	Workload (Util)
Replication	1	1	45.96
Replication	2	2	45.89
Replication	3	3	45.95
Replication	4	4	45.91
Replication	5	5	45.63
Replication	6	x	
Replication	7	x	
Replication	8	x	
Replication	9	6	45.97
Replication	10	7	46.02
Replication	11	8	45.97
Replication	12	9	45.99
Replication	13	10	45.84
Replication	14	11	45.87
Replication	15	12	45.86
Replication	16	13	45.90
Replication	17	x	
Replication	18	14	45.95
Replication	19	15	46.09
Replication	20	n	
Average	15		45.92

Random # Seed = 1.0

T8-KSA-PPPPP

Battalion Commander	#	Adj #	Workload (Util)
Replication	1	1	47.48
Replication	2	2	47.33
Replication	3	3	47.42
Replication	4	4	47.32
Replication	5	5	47.02
Replication	6	x	
Replication	7	x	
Replication	8	x	
Replication	9	6	47.38
Replication	10	7	47.49
Replication	11	8	47.37
Replication	12	9	47.43
Replication	13	10	47.15
Replication	14	11	47.21
Replication	15	12	47.27
Replication	16	13	
Replication	17	x	
Replication	18	14	47.33
Replication	19	15	47.50
Replication	20	n	
Average	15		44.18

Data From Fractional Factorial- Task Time Runs.

Random # Seed = 1.0 T1-TTime-PMMMM

Battalion Commander	#	Adj #	Taskload (Workload) (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.23					
Replication	2	2	39.15					
Replication	3	3	39.34					
Replication	4	4	39.29					
Replication	5	5	39.30					
Replication	6	6	39.34					
Replication	7	7	39.31					
Replication	8	8	39.25					
Replication	9	9	39.29					
Replication	10	10	39.17					
Replication	11	11	39.29					
Replication	12	12	39.31					
Replication	13	13	39.40					
Replication	14	14	39.24					
Replication	15	15	39.23					
Replication	16	n						
Replication	17	n						
Replication	18	n						
Replication	19	n						
Replication	20	n						
Average	15		39.28	0.9250	49.33	90.33	10.47	9.60

Random # Seed = 1.0 T2-TTime-MPPMM

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	x						
Replication	2	x						
Replication	3	x						
Replication	4	x						
Replication	5	1	40.18					
Replication	6	x						
Replication	7	x						
Replication	8	2	40.21					
Replication	9	x						
Replication	10	3	40.05					
Replication	11	x						
Replication	12	4	40.40					
Replication	13	x						
Replication	14	x						
Replication	15	5	39.86					
Replication	16	x						
Replication	17	x						
Replication	18	x						
Replication	19	x						
Replication	20	6	39.86					
Replication	21	7	40.06					
Replication	SR1	x						
Replication	SR2	8	40.00					
Replication	SR3	x						
Replication	SR4	x						
Replication	SR5	x						
Replication	SR6	9	40.16					
Replication	SR7	x						
Replication	SR8	x						
Replication	SR9	x						
Replication	SR10	x						
Replication	SR11	10	40.11					
Replication	SR12	x						
Replication	SR13	11	40.36					
Replication	SR14	12	40.10					
Replication	2SR1	x						
Replication	2SR2	x						
Replication	2SR3	x						
Replication	2SR4	x						
Replication	2SR5	x						
Replication	2SR6	x						
Replication	2SR7	x						
Replication	2SR8	13	40.16					
Replication	2SR9	x						
Replication	2SR10	14	39.93					
Replication	2SR11	x						
Replication	2SR12	x						
Replication	2SR13	x						
Replication	2SR14	x						
Replication	2SR15	x						
Replication	2SR16	15	39.80					
Average	15		40.08	0.93	47.13	89.07	10.33	9.40

Random # Seed = 1.0 T3-TTime-PPMPM

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	38.73					
Replication	2	2	38.36					
Replication	3	3	38.51					
Replication	4	4	38.58					
Replication	5	5	38.51					
Replication	6	6	38.71					
Replication	7	7	38.59					
Replication	8	8	38.60					
Replication	9	9	38.64					
Replication	10	10	38.66					
Replication	11	x						
Replication	12	11	38.57					
Replication	13	12	38.69					
Replication	14	13	38.53					
Replication	15	14	38.37					
Replication	16	x						
Replication	17	x						
Replication	18	15	38.76					
Replication	19	n						
Replication	20	n						
Average	15		38.59	0.9213	55.13	88.47	10.47	14.20

Random # Seed = 1.0 T4-TTime-MMPPM

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.69					
Replication	2	x						
Replication	3	x						
Replication	4	x						
Replication	5	x						
Replication	6	2	39.51					
Replication	7	3	39.17					
Replication	8	4	39.21					
Replication	9	5	39.32					
Replication	10	6	39.48					
Replication	11	7	39.25					
Replication	12	x						
Replication	13	8	39.37					
Replication	14	9	39.58					
Replication	15	10						
Replication	16	x						
Replication	17	x						
Replication	18	x						
Replication	19	11	39.65					
Replication	20	12	39.19					
Replication	21	13	39.55					
Replication	22	x						
Replication	23	x						
Replication	24	14	39.27					
Replication	25	15	39.64					
Average	15		36.79	0.9242	51.73	88.47	10.67	12.20

Random # Seed = 1.0 T5-TTime-MPMMP

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.91					
Replication	2	x						
Replication	3	2	39.56					
Replication	4	3	39.81					
Replication	5	x						
Replication	6	x						
Replication	7	x						
Replication	8	4	39.87					
Replication	9	5	39.71					
Replication	10	6	39.62					
Replication	11	7	39.71					
Replication	12	8	39.99					
Replication	13	9	40.12					
Replication	14	x						
Replication	15	10	39.76					
Replication	16	11	40.09					
Replication	17	x						
Replication	18	12	39.66					
Replication	19	13	40.03					
Replication	20	14	39.70					
Replication	21	x						
Replication	22	x						
Replication	23	x						
Replication	24	x						
Replication	25	x						
Replication	26	15	39.60					
Replication	27	x						
Average	15		39.81	0.9242	42.80	90.87	10.40	8.93

Random # Seed = 1.0 T6-TTime-PMPMP

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.57					
Replication	2	2	39.44					
Replication	3	3	39.52					
Replication	4	4	39.43					
Replication	5	5	39.18					
Replication	6	x						
Replication	7	x						
Replication	8	x						
Replication	9	6	39.49					
Replication	10	7	39.57					
Replication	11	8	39.48					
Replication	12	9	39.53					
Replication	13	10	39.29					
Replication	14	11	39.34					
Replication	15	12	39.39					
Replication	16	13	39.33					
Replication	17	x						
Replication	18	14	39.44					
Replication	19	15	39.58					
Replication	20	n						
Average	15		39.44	0.9244	50.60	90.27	10.80	10.93

Random # Seed = 1.0 Treatment Level = 20% T7-TTime-MMMPP

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.28					
Replication	2	2	39.22					
Replication	3	3	39.23					
Replication	4	4	39.19					
Replication	5	5	39.22					
Replication	6	x						
Replication	7	6	39.26					
Replication	8	7	39.17					
Replication	9	x						
Replication	10	8	39.08					
Replication	11	9	39.35					
Replication	12	10	39.32					
Replication	13	11	39.20					
Replication	14	x						
Replication	15	12	39.26					
Replication	16	13	39.37					
Replication	17	14	38.95					
Replication	18	15	39.15					
Replication	19	n						
Replication	20	x						
Average	15		39.22	0.9240	48.27	89.07	10.40	11.07

Random # Seed = 1.0 T8-TTime-PPPPP

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	38.97					
Replication	2	2	38.80					
Replication	3	3	38.89					
Replication	4	4	38.93					
Replication	5	5	38.79					
Replication	6	6	38.63					
Replication	7	7	38.66					
Replication	8	8	39.03					
Replication	9	9	39.08					
Replication	10	10	38.86					
Replication	11	11	38.78					
Replication	12	12	38.98					
Replication	13	13	38.84					
Replication	14	14	39.24					
Replication	15	15	38.88					
Replication	16	n						
Replication	17	n						
Replication	18	n						
Replication	19	n						
Replication	20	n						
Average	15		38.89	0.9183	58.47	87.27	9.47	15.33

Data From Center Point Runs.

Treatment # 9 Random # Seed = 1.0000

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.57					
Replication	2	2	39.44					
Replication	3	3	39.52					
Replication	4	4	39.43					
Replication	5	5	39.18					
Replication	6	x						
Replication	7	x						
Replication	8	x						
Replication	9	6	39.49					
Replication	10	7	39.57					
Replication	11	8	39.48					
Replication	12	9	39.53					
Replication	13	10	39.29					
Replication	14	11	39.34					
Replication	15	12	39.39					
Replication	16	13	39.33					
Replication	17	x						
Replication	18	14	39.44					
Replication	19	15	39.58					
Replication	20	n						
Average	15		39.44	0.9244	50.60	90.27	10.80	10.93

Treatment # 10 Random # Seed = 2.00

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.41					
Replication	2	2	39.43					
Replication	3	3	39.45					
Replication	4	4	39.51					
Replication	5	x						
Replication	6	5	39.62					
Replication	7	6	39.29					
Replication	8	7	39.06					
Replication	9	8	39.36					
Replication	10	x						
Replication	11	9	39.50					
Replication	12	10	39.52					
Replication	13	11	39.60					
Replication	14	12	39.30					
Replication	15	13	39.15					
Replication	16	14	39.29					
Replication	17	x						
Replication	18	x						
Replication	19	15	39.39					
Replication	20	n						
Average	15		39.39	0.9240	49.87	90.47	10.60	11.13

Treatment # 11 Random # Seed = 3.00

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.30					
Replication	2	2	39.53					
Replication	3	3	39.44					
Replication	4	4	39.35					
Replication	5	5	39.48					
Replication	6	6	39.31					
Replication	7	7	39.52					
Replication	8	8	39.42					
Replication	9	x						
Replication	10	x						
Replication	11	x						
Replication	12	9	39.39					
Replication	13	10	39.26					
Replication	14	11	39.45					
Replication	15	12	39.20					
Replication	16	13	39.35					
Replication	17	14	39.15					
Replication	18	15	39.41					
Replication	19	n						
Replication	20	n						
Average	15		39.37	0.9242	49.87	89.87	10.80	11.13

Treatment # 12 Random # Seed = 4.00

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.60					
Replication	2	2	39.44					
Replication	3	3	39.52					
Replication	4	4	39.29					
Replication	5	5	39.60					
Replication	6	x						
Replication	7	x						
Replication	8	6	39.27					
Replication	9	7	39.22					
Replication	10	x						
Replication	11	8	39.23					
Replication	12	x						
Replication	13	9	39.28					
Replication	14	10	39.27					
Replication	15	11	39.34					
Replication	16	12	39.24					
Replication	17	x						
Replication	18	13	39.40					
Replication	19	14	39.25					
Replication	20	15	39.30					
Average	15		39.35	0.9243	49.53	90.13	10.93	10.53

Treatment # 13 Random # Seed = 5

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.29					
Replication	2	2	39.34					
Replication	3	3	39.36					
Replication	4	4	39.57					
Replication	5	5	39.51					
Replication	6	6	39.53					
Replication	7	7	39.34					
Replication	8	8	39.49					
Replication	9	9	39.38					
Replication	10	x						
Replication	11	10	39.48					
Replication	12	11	39.36					
Replication	13	12	39.14					
Replication	14	13	39.34					
Replication	15	14	39.46					
Replication	16	x						
Replication	17	15	39.54					
Replication	18	n						
Replication	19	x						
Replication	20	x						
Average	15		39.41	0.9246	50.93	89.60	10.73	10.47

Treatment # 14 Random # Seed = 6

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	x						
Replication	2	1	39.31					
Replication	3	2	39.24					
Replication	4	3	39.26					
Replication	5	4	39.30					
Replication	6	5	39.53					
Replication	7	6	39.43					
Replication	8	7	39.52					
Replication	9	x						
Replication	10	x						
Replication	11	8	39.26					
Replication	12	x						
Replication	13	9	39.59					
Replication	14	10	39.44					
Replication	15	11	39.26					
Replication	16	12	39.66					
Replication	17	13	39.32					
Replication	18	x						
Replication	19	14	39.09					
Replication	20	15	39.31					
Average	15		39.37	0.9244	49.67	89.60	10.80	10.93

Treatment # 15 Random # Seed = 7

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.16					
Replication	2	2	39.23					
Replication	3	x						
Replication	4	3	39.48					
Replication	5	4	39.43					
Replication	6	5	39.27					
Replication	7	6	39.42					
Replication	8	x						
Replication	9	x						
Replication	10	7	39.36					
Replication	11	8	39.36					
Replication	12	9	39.08					
Replication	13	10	39.19					
Replication	14	x						
Replication	15	11	39.19					
Replication	16	x						
Replication	17	12	39.37					
Replication	18	13	39.58					
Replication	19	x						
Replication	20	14	39.24					
Replication	21	15	39.45					
Replication	22	n						
Average	15		39.32	0.9246	49.07	90.27	10.73	10.93

Treatment # 16 Random # Seed = 8

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.08					
Replication	2	2	39.60					
Replication	3	3	39.25					
Replication	4	4	39.41					
Replication	5	5	39.44					
Replication	6	6	39.36					
Replication	7	7	39.16					
Replication	8	x						
Replication	9	x						
Replication	10	8	39.42					
Replication	11	x						
Replication	12	9	39.38					
Replication	13	x						
Replication	14	10	39.44					
Replication	15	11	39.51					
Replication	16	12	39.41					
Replication	17	13	39.25					
Replication	18	14	39.21					
Replication	19	15	39.28					
Replication	20	n						
Average	15		39.35	0.9239	49.73	89.87	10.87	10.60

Treatment # 17 Random # Seed = 9

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.40					
Replication	2	x						
Replication	3	2	39.32					
Replication	4	3	39.56					
Replication	5	4	39.42					
Replication	6	x						
Replication	7	5	39.41					
Replication	8	6	39.45					
Replication	9	7	39.29					
Replication	10	x						
Replication	11	x						
Replication	12	x						
Replication	13	8	39.36					
Replication	14	9	39.59					
Replication	15	x						
Replication	16	10	39.15					
Replication	17	11	45.50					
Replication	18	12	45.72					
Replication	19	x						
Replication	20	13	39.27					
Replication	21	x						
Replication	22	14	39.25					
Replication	23	x						
Replication	24	15	39.41					
Replication	25	x						
Average	15		40.21	0.9235	50.00	89.87	10.80	10.87

Treatment # 18 Random # Seed = 10

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.41					
Replication	2	x						
Replication	3	x						
Replication	4	x						
Replication	5	2	39.37					
Replication	6	3	39.46					
Replication	7	4	39.44					
Replication	8	5	39.31					
Replication	9	6	39.36					
Replication	10	7	39.51					
Replication	11	8	39.24					
Replication	12	x						
Replication	13	9	39.18					
Replication	14	x						
Replication	15	10	39.29					
Replication	16	11	39.37					
Replication	17	12	39.39					
Replication	18	13	39.28					
Replication	19	14	39.31					
Replication	20	x						
Replication	21	15	39.19					
Replication	22	n						
Average	15		39.34	0.9238	50.07	89.67	10.73	11.20

Treatment # 19 Random # Seed = 11

Battalion Commander	#	Adj #	Workload (Util)	Utilization (Util)	Number of Queues (Opdata)	Tasks Interrupted (Opdata)	Tasks Suspended (Opdata)	Tasks Dropped (Opdata)
Replication	1	1	39.56					
Replication	2	2	39.07					
Replication	3	3	39.33					
Replication	4	4	39.01					
Replication	5	5	39.44					
Replication	6	6	39.29					
Replication	7	7	39.31					
Replication	8	8	39.59					
Replication	9	9	39.55					
Replication	10	x						
Replication	11	10	39.29					
Replication	12	11	39.55					
Replication	13	12	39.45					
Replication	14	x						
Replication	15	13	39.55					
Replication	16	14	39.20					
Replication	17	15	39.53					
Replication	18	n						
Replication	19	x						
Replication	20	n						
Average	15		39.38	0.9246	50.40	89.80	10.60	10.80

Appendix E – Multicollinearity Tests.

SAS Program – PROC CORR.

```
options pageno=1 formdlim='-';
  TITLE 'CoHOST 1/4 Replicate of 2**5 Design';
 DATA cohost;
 INPUT car drd eei usp mrs subj tltt tlksa util noque tskint tsksup tskdrp;
* Independent variables - Factors:;
*   Factor A:  CAR - Communicate and Report;
*   Factor B:  DRD - Decide and Recommend / Direct;
*   Factor C:  EEI - Evaluate and Estimate Impact;
*   Factor D:  USP - Identify / Understand Situational Picture;
*   Factor E:  MRS - Manage Resources;
*   Simulated subjects:  subj;
*;
* Dependent variables:;
*   TLTT - Taskload from Workload in the Task Time runs;
*   TLKSA - Taskload from Workload in the KSA / JASS data runs;
*   UTIL - % Utilization over run;
*   NOQUE - Number of queues generated during the run, ;
*           i.e., the number of times a task was queued up;
*   TSKINT - Number of times a task was interrupted;
*   TSKSUP - Number of times a task was suspended;
*   TSKDRP - Number of times a task was dropped;
*;
* Provide input data as CARDS statements ;
* 1/4 replicate portion:  ;
* 5 Factors - 2 levels/factor= 32 Treatment Combinations x    ;
*                               1 subject per cell =     ;
*                              32 Treatments if full factorial;
*                               8 Treatments for 1/4 fractional factorial;
* Central composite center point treatment:  ;
* 11 treatments on center point to provide 3rd treatment level;
*;
 CARDS;
1       -1      -1      -1      -1      1       39.275  31.884  0.9250  49.33   90.33   10.47   9.60
-1      1       1       -1      -1      1       40.084  32.625  0.9256  47.13   89.07   10.33   9.40
1       1       -1      1       -1      1       38.588  46.259  0.9213  55.13   88.47   10.47   14.20
-1      -1      1       1       -1      1       36.793  46.988  0.9242  51.73   88.47   10.67   12.20
-1      1       -1      -1      1       1       39.810  31.557  0.9242  42.80   90.87   10.40   8.93
1       -1      1       -1      1       1       39.439  32.952  0.9244  50.60   90.27   10.80   10.93
-1      -1      -1      1       1       1       39.217  45.920  0.9240  48.27   89.07   10.40   11.07
1       1       1       1       1       1       38.891  44.180  0.9183  58.47   87.27   9.47    15.33
0       0       0       0       0       1       39.439  39.439  0.9244  50.60   90.27   10.80   10.93
0       0       0       0       0       2       39.391  39.391  0.9240  49.87   90.47   10.60   11.13
0       0       0       0       0       3       39.372  39.372  0.9242  49.87   89.87   10.80   11.13
0       0       0       0       0       4       39.351  39.351  0.9243  49.53   90.13   10.93   10.53
0       0       0       0       0       5       39.407  39.407  0.9246  50.93   89.60   10.73   10.47
0       0       0       0       0       6       39.367  39.367  0.9244  49.67   89.60   10.80   10.93
0       0       0       0       0       7       39.320  39.320  0.9246  49.07   90.27   10.73   10.93
0       0       0       0       0       8       39.346  39.346  0.9239  49.73   89.87   10.87   10.60
0       0       0       0       0       9       40.207  40.207  0.9235  50.00   89.87   10.80   10.87
0       0       0       0       0       10      39.340  39.340  0.9238  50.07   89.67   10.73   11.20
0       0       0       0       0       11      39.382  39.382  0.9246  50.40   89.80   10.60   10.80
;
*  Regression Runs:          ;
*    First, test for any multicollinearity problems:  ;
 options pageno=1 formdlim='-';
*        Generate a full correlation table:    ;
* ;
proc corr data=cohost;
  TITLE 'CoHOST Dependent Variable Correlation Matrix:  Multicollinearity Test';
              var car drd eei usp mrs tltt tlksa util noque tskint tsksup tskdrp;
run;
```

SAS Output – PROC CORR.

The CORR Procedure

12 Variables: car drd eei usp mrs tltt tlksa util noque tskint tsksup tskdrp

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
car	19	0	0.66667	0	-1.00000	1.00000
drd	19	0	0.66667	0	-1.00000	1.00000
eei	19	0	0.66667	0	-1.00000	1.00000
usp	19	0	0.66667	0	-1.00000	1.00000
mrs	19	0	0.66667	0	-1.00000	1.00000
tltt	19	39.26416	0.69607	746.01900	36.79300	40.20700
tlksa	19	39.27826	4.56953	746.28700	31.55700	46.98800
util	19	0.92386	0.00158	17.55330	0.91830	0.92560
noque	19	50.16842	3.04669	953.20000	42.80000	58.47000
tskint	19	89.64421	0.85963	1703	87.27000	90.87000
tsksup	19	10.60000	0.32498	201.40000	9.47000	10.93000
tskdrp	19	11.11474	1.48699	211.18000	8.93000	15.33000

Pearson Correlation Coefficients, N = 19
Prob > |r| under H0: Rho=0

	car	drd	eei	usp	mrs	tltt
car	1.00000	0.00000	0.00000	0.00000	0.00000	0.03460
		1.0000	1.0000	1.0000	1.0000	0.8882
drd	0.00000	1.00000	0.00000	0.00000	0.00000	0.31714
	1.0000		1.0000	1.0000	1.0000	0.1858
eei	0.00000	0.00000	1.00000	0.00000	0.00000	-0.20149
	1.0000	1.0000		1.0000	1.0000	0.4081
usp	0.00000	0.00000	0.00000	1.00000	0.00000	-0.61284
	1.0000	1.0000	1.0000		1.0000	0.0053
mrs	0.00000	0.00000	0.00000	0.00000	1.00000	0.31331
	1.0000	1.0000	1.0000	1.0000		0.1915
tltt	0.03460	0.31714	-0.20149	-0.61284	0.31331	1.00000
	0.8882	0.1858	0.4081	0.0053	0.1915	
tlksa	-0.03310	-0.05695	0.02052	0.99078	-0.05739	-0.62500
	0.8930	0.8169	0.9336	<.0001	0.8155	0.0042
util	-0.47420	-0.43205	-0.10538	-0.60066	-0.27398	0.24293
	0.0402	0.0647	0.6677	0.0065	0.2563	0.3163
noque	0.64551	0.09847	0.33917	0.64934	-0.08698	-0.44265
	0.0028	0.6884	0.1555	0.0026	0.7233	0.0577
tskint	-0.11051	-0.23848	-0.35480	-0.70379	0.11051	0.50882
	0.6524	0.3255	0.1361	0.0008	0.6524	0.0261
tsksup	-0.15129	-0.42823	-0.12052	-0.25386	-0.22309	0.09853
	0.5364	0.0674	0.6231	0.2943	0.3586	0.6882
tskdrp	0.47411	0.22753	0.22753	0.78122	0.04820	-0.50938
	0.0403	0.3489	0.3489	<.0001	0.8447	0.0259

Pearson Correlation Coefficients, N = 19
Prob > |r| under H0: Rho=0

	tlksa	util	noque	tskint	tsksup	tskdrp
car	-0.03310	-0.47420	0.64551	-0.11051	-0.15129	0.47411
	0.8930	0.0402	0.0028	0.6524	0.5364	0.0403
drd	-0.05695	-0.43205	0.09847	-0.23848	-0.42823	0.22753
	0.8169	0.0647	0.6884	0.3255	0.0674	0.3489
eei	0.02052	-0.10538	0.33917	-0.35480	-0.12052	0.22753
	0.9336	0.6677	0.1555	0.1361	0.6231	0.3489
usp	0.99078	-0.60066	0.64934	-0.70379	-0.25386	0.78122
	<.0001	0.0065	0.0026	0.0008	0.2943	<.0001
mrs	-0.05739	-0.27398	-0.08698	0.11051	-0.22309	0.04820
	0.8155	0.2563	0.7233	0.6524	0.3586	0.8447
tltt	-0.62500	0.24293	-0.44265	0.50882	0.09853	-0.50938
	0.0042	0.3163	0.0577	0.0261	0.6882	0.0259
tlksa	1.00000	-0.51917	0.61908	-0.66283	-0.14484	0.73953
		0.0227	0.0047	0.0020	0.5541	0.0003
util	-0.51917	1.00000	-0.77935	0.71330	0.71186	-0.89196
	0.0227		<.0001	0.0006	0.0006	<.0001
noque	0.61908	-0.77935	1.00000	-0.74302	-0.42306	0.91791
	0.0047	<.0001		0.0003	0.0711	<.0001
tskint	-0.66283	0.71330	-0.74302	1.00000	0.66042	-0.80005
	0.0020	0.0006	0.0003		0.0021	<.0001
tsksup	-0.14484	0.71186	-0.42306	0.66042	1.00000	-0.52516
	0.5541	0.0006	0.0711	0.0021		0.0210
tskdrp	0.73953	-0.89196	0.91791	-0.80005	-0.52516	1.00000
	0.0003	<.0001	<.0001	<.0001	0.0210	

Appendix F – Determination Of Multiple Linear Regression Models For Standardized Data.

SAS PROC REG for MLR Model Run.

The multiple linear regression model to be used in this thesis is determined by SAS runs that generate the regression parameter estimates (beta weights) for each dependent variable. The MRS independent variable for each dependent variable is examined to identify the smallest p value. This value is then used as a threshold to determine which of the other coefficients are significant and whose value should be included in the regression model for that dependent variable.

```
options pageno=1 formdlim='-';
  TITLE 'CoHOST 1/4 Replicate of 2**5 Design';
 DATA cohost;
 INPUT car drd eei usp mrs subj tltt tlksa util noque tskint tsksup tskdrp;
* Independent variables - Factors:;
*   Factor A:  CAR - Communicate and Report;
*   Factor B:  DRD - Decide and Recommend / Direct;
*   Factor C:  EEI - Evaluate and Estimate Impact;
*   Factor D:  USP - Identify / Understand Situational Picture;
*   Factor E:  MRS - Manage Resources;
*   Simulated subjects:  subj;
*;
* Dependent variables:;
*   TLTT - Taskload from Workload in the Task Time runs;
*   TLKSA - Taskload from Workload in the KSA / JASS data runs;
*   UTIL - % Utilization over run;
*   NOQUE - Number of queues generated during the run, ;
*           i.e., the number of times a task was queued up;
*   TSKINT - Number of times a task was interrupted;
*   TSKSUP - Number of times a task was suspended;
*   TSKDRP - Number of times a task was dropped;
*;
* Provide input data as CARDS statements ;
* 1/4 replicate portion:  ;
* 5 Factors - 2 levels/factor= 32 Treatment Combinations x    ;
*                               1 subject per cell =     ;
*                              32 Treatments if full factorial;
*                               8 Treatments for 1/4 fractional factorial;
* Central composite center point treatment:  ;
* 11 treatments on center point to provide 3rd treatment level;
*;
 CARDS;
1       -1      -1      -1      -1      1       39.275  31.884  0.9250  49.33   90.33   10.47   9.60
-1      1       1       -1      -1      1       40.084  32.625  0.9256  47.13   89.07   10.33   9.40
1       1       -1      1       -1      1       38.588  46.259  0.9213  55.13   88.47   10.47   14.20
-1      -1      1       1       -1      1       36.793  46.988  0.9242  51.73   88.47   10.67   12.20
-1      1       -1      -1      1       1       39.810  31.557  0.9242  42.80   90.87   10.40   8.93
1       -1      1       -1      1       1       39.439  32.952  0.9244  50.60   90.27   10.80   10.93
-1      -1      -1      1       1       1       39.217  45.920  0.9240  48.27   89.07   10.40   11.07
1       1       1       1       1       1       38.891  44.180  0.9183  58.47   87.27   9.47    15.33
0       0       0       0       0       1       39.439  39.439  0.9244  50.60   90.27   10.80   10.93
0       0       0       0       0       2       39.391  39.391  0.9240  49.87   90.47   10.60   11.13
0       0       0       0       0       3       39.372  39.372  0.9242  49.87   89.87   10.80   11.13
0       0       0       0       0       4       39.351  39.351  0.9243  49.53   90.13   10.93   10.53
0       0       0       0       0       5       39.407  39.407  0.9246  50.93   89.60   10.73   10.47
0       0       0       0       0       6       39.367  39.367  0.9244  49.67   89.60   10.80   10.93
0       0       0       0       0       7       39.320  39.320  0.9246  49.07   90.27   10.73   10.93
0       0       0       0       0       8       39.346  39.346  0.9239  49.73   89.87   10.87   10.60
0       0       0       0       0       9       40.207  40.207  0.9235  50.00   89.87   10.80   10.87
0       0       0       0       0       10      39.340  39.340  0.9238  50.07   89.67   10.73   11.20
0       0       0       0       0       11      39.382  39.382  0.9246  50.40   89.80   10.60   10.80
```

```
;
*;
 options pageno=1 formdlim='-';
*    Use straight proc reg on standardized data to build the regression models ;
*  Standardize the data and rerun;
 options pageno=1 formdlim='-';
proc standard mean=0 std=1 out=cohosts data=cohost;
       var tltt tlksa util noque tskint tsksup tskdrp;
run;
proc reg corr data=cohosts;
  TITLE 'CoHOST Multiple Linear Regression Model/ Standardized Data- Variable TLTT';
              model tltt = car drd eei usp mrs;
run;
proc reg corr data=cohosts;
  TITLE 'CoHOST Multiple Linear Regression Model/ Standardized Data- Variable TLKSA';
              model tlksa = car drd eei usp mrs;
run;
proc reg corr data=cohosts;
  TITLE 'CoHOST Multiple Linear Regression Model/ Standardized Data- Variable UTIL';
              model util = car drd eei usp mrs;
run;
proc reg corr data=cohosts;
  TITLE 'CoHOST Multiple Linear Regression Model/ Standardized Data- Variable NOQUE';
              model noque = car drd eei usp mrs;
run;
proc reg corr data=cohosts;
  TITLE 'CoHOST Multiple Linear Regression Model/ Standardized Data- Variable TSKINT';
              model tskint = car drd eei usp mrs;
run;
proc reg corr data=cohosts;
  TITLE 'CoHOST Multiple Linear Regression Model/ Standardized Data- Variable TSKSUP';
              model tsksup = car drd eei usp mrs;
run;
proc reg corr data=cohosts;
  TITLE 'CoHOST Multiple Linear Regression Model/ Standardized Data- Variable TSKDRP';
              model tskdrp = car drd eei usp mrs;
run;
*;
*;
```

SAS Output – PROC REG.

CoHOST Multiple Linear Regression Model/ Standardized Data- Variable TLTT 1
11:07 Thursday, July 5, 2001

The REG Procedure
Correlation

Variable	car	drd	eei	usp	mrs	tltt
car	1.0000	0.0000	0.0000	0.0000	0.0000	0.0346
drd	0.0000	1.0000	0.0000	0.0000	0.0000	0.3171
eei	0.0000	0.0000	1.0000	0.0000	0.0000	-0.2015
usp	0.0000	0.0000	0.0000	1.0000	0.0000	-0.6128
mrs	0.0000	0.0000	0.0000	0.0000	1.0000	0.3133
tltt	0.0346	0.3171	-0.2015	-0.6128	0.3133	1.0000

CoHOST Multiple Linear Regression Model/ Standardized Data- Variable TLTT 2
11:07 Thursday, July 5, 2001

The REG Procedure
Model: MODEL1
Dependent Variable: tltt
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	11.08997	2.21799	4.17	0.0176
Error	13	6.91003	0.53154		
Corrected Total	18	18.00000			

Root MSE	0.72907	R-Square	0.6161
Dependent Mean	-8.0637E-15	Adj R-Sq	0.4685
Coeff Var	-9.04133E15		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-8.0637E-15	0.16726	-0.00	1.0000
car	1	0.05190	0.25776	0.20	0.8435
drd	1	0.47571	0.25776	1.85	0.0879
eei	1	-0.30223	0.25776	-1.17	0.2620
usp	1	-0.91927	0.25776	-3.57	0.0034
mrs	1	0.46996	0.25776	1.82	0.0913

CoHOST Multiple Linear Regression Model/ Standardized Data- Variable TLKSA 3
11:07 Thursday, July 5, 2001

The REG Procedure
Correlation

Variable	car	drd	eei	usp	mrs	tlksa
car	1.0000	0.0000	0.0000	0.0000	0.0000	-0.0331
drd	0.0000	1.0000	0.0000	0.0000	0.0000	-0.0570
eei	0.0000	0.0000	1.0000	0.0000	0.0000	0.0205
usp	0.0000	0.0000	0.0000	1.0000	0.0000	0.9908
mrs	0.0000	0.0000	0.0000	0.0000	1.0000	-0.0574
tlksa	-0.0331	-0.0570	0.0205	0.9908	-0.0574	1.0000

CoHOST Multiple Linear Regression Model/ Standardized Data- Variable TLKSA 4
11:07 Thursday, July 5, 2001

The REG Procedure
Model: MODEL1
Dependent Variable: tlksa
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	17.81469	3.56294	249.95	<.0001
Error	13	0.18531	0.01425		
Corrected Total	18	18.00000			

Root MSE	0.11939	R-Square	0.9897
Dependent Mean	-1.1931E-15	Adj R-Sq	0.9857
Coeff Var	-1.00067E16		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-1.1931E-15	0.02739	-0.00	1.0000
car	1	-0.04965	0.04221	-1.18	0.2606
drd	1	-0.08543	0.04221	-2.02	0.0640
eei	1	0.03077	0.04221	0.73	0.4789
usp	1	1.48617	0.04221	35.21	<.0001
mrs	1	-0.08609	0.04221	-2.04	0.0623

The REG Procedure
Correlation

Variable	car	drd	eei	usp	mrs	util
car	1.0000	0.0000	0.0000	0.0000	0.0000	-0.4742
drd	0.0000	1.0000	0.0000	0.0000	0.0000	-0.4321
eei	0.0000	0.0000	1.0000	0.0000	0.0000	-0.1054
usp	0.0000	0.0000	0.0000	1.0000	0.0000	-0.6007
mrs	0.0000	0.0000	0.0000	0.0000	1.0000	-0.2740
util	-0.4742	-0.4321	-0.1054	-0.6007	-0.2740	1.0000

The REG Procedure
Model: MODEL1
Dependent Variable: util
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	15.45296	3.09059	15.77	<.0001
Error	13	2.54704	0.19593		
Corrected Total	18	18.00000			

Root MSE	0.44264	R-Square	0.8585
Dependent Mean	-1.3302E-13	Adj R-Sq	0.8041
Coeff Var	-3.32753E14		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-1.3302E-13	0.10155	-0.00	1.0000
car	1	-0.71130	0.15650	-4.55	0.0005
drd	1	-0.64808	0.15650	-4.14	0.0012
eei	1	-0.15807	0.15650	-1.01	0.3309
usp	1	-0.90099	0.15650	-5.76	<.0001
mrs	1	-0.41098	0.15650	-2.63	0.0209

CoHOST Multiple Linear Regression Model/ Standardized Data- Variable NOQUE 7
11:07 Thursday, July 5, 2001

The REG Procedure
Correlation

Variable	car	drd	eei	usp	mrs	noque
car	1.0000	0.0000	0.0000	0.0000	0.0000	0.6455
drd	0.0000	1.0000	0.0000	0.0000	0.0000	0.0985
eei	0.0000	0.0000	1.0000	0.0000	0.0000	0.3392
usp	0.0000	0.0000	0.0000	1.0000	0.0000	0.6493
mrs	0.0000	0.0000	0.0000	0.0000	1.0000	-0.0870
noque	0.6455	0.0985	0.3392	0.6493	-0.0870	1.0000

CoHOST Multiple Linear Regression Model/ Standardized Data- Variable NOQUE 8
11:07 Thursday, July 5, 2001

The REG Procedure
Model: MODEL1
Dependent Variable: noque
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	17.47113	3.49423	85.89	<.0001
Error	13	0.52887	0.04068		
Corrected Total	18	18.00000			

Root MSE	0.20170	R-Square	0.9706
Dependent Mean	-2.4688E-16	Adj R-Sq	0.9593
Coeff Var	-8.16996E16		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-2.4688E-16	0.04627	-0.00	1.0000
car	1	0.96826	0.07131	13.58	<.0001
drd	1	0.14770	0.07131	2.07	0.0588
eei	1	0.50875	0.07131	7.13	<.0001
usp	1	0.97401	0.07131	13.66	<.0001
mrs	1	-0.13047	0.07131	-1.83	0.0903

The REG Procedure
Correlation

Variable	car	drd	eei	usp	mrs	tskint
car	1.0000	0.0000	0.0000	0.0000	0.0000	-0.1105
drd	0.0000	1.0000	0.0000	0.0000	0.0000	-0.2385
eei	0.0000	0.0000	1.0000	0.0000	0.0000	-0.3548
usp	0.0000	0.0000	0.0000	1.0000	0.0000	-0.7038
mrs	0.0000	0.0000	0.0000	0.0000	1.0000	0.1105
tskint	-0.1105	-0.2385	-0.3548	-0.7038	0.1105	1.0000

The REG Procedure
Model: MODEL1
Dependent Variable: tskint
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	12.64515	2.52903	6.14	0.0039
Error	13	5.35485	0.41191		
Corrected Total	18	18.00000			

Root MSE	0.64180	R-Square	0.7025
Dependent Mean	3.21512E-14	Adj R-Sq	0.5881
Coeff Var	1.996204E15		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.21512E-14	0.14724	0.00	1.0000
car	1	-0.16577	0.22691	-0.73	0.4780
drd	1	-0.35771	0.22691	-1.58	0.1389
eei	1	-0.53221	0.22691	-2.35	0.0355
usp	1	-1.05569	0.22691	-4.65	0.0005
mrs	1	0.16577	0.22691	0.73	0.4780

The REG Procedure
Correlation

Variable	car	drd	eei	usp	mrs	tsksup
car	1.0000	0.0000	0.0000	0.0000	0.0000	-0.1513
drd	0.0000	1.0000	0.0000	0.0000	0.0000	-0.4282
eei	0.0000	0.0000	1.0000	0.0000	0.0000	-0.1205
usp	0.0000	0.0000	0.0000	1.0000	0.0000	-0.2539
mrs	0.0000	0.0000	0.0000	0.0000	1.0000	-0.2231
tsksup	-0.1513	-0.4282	-0.1205	-0.2539	-0.2231	1.0000

The REG Procedure
Model: MODEL1
Dependent Variable: tsksup
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	6.03026	1.20605	1.31	0.3190
Error	13	11.96974	0.92075		
Corrected Total	18	18.00000			

Root MSE	0.95956	R-Square	0.3350
Dependent Mean	2.03638E-15	Adj R-Sq	0.0793
Coeff Var	4.712065E16		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	2.03638E-15	0.22014	0.00	1.0000
car	1	-0.22694	0.33925	-0.67	0.5152
drd	1	-0.64235	0.33925	-1.89	0.0808
eei	1	-0.18078	0.33925	-0.53	0.6031
usp	1	-0.38079	0.33925	-1.12	0.2820
mrs	1	-0.33464	0.33925	-0.99	0.3419

The REG Procedure
Correlation

Variable	car	drd	eei	usp	mrs	tskdrp
car	1.0000	0.0000	0.0000	0.0000	0.0000	0.4741
drd	0.0000	1.0000	0.0000	0.0000	0.0000	0.2275
eei	0.0000	0.0000	1.0000	0.0000	0.0000	0.2275
usp	0.0000	0.0000	0.0000	1.0000	0.0000	0.7812
mrs	0.0000	0.0000	0.0000	0.0000	1.0000	0.0482
tskdrp	0.4741	0.2275	0.2275	0.7812	0.0482	1.0000

The REG Procedure
Model: MODEL1
Dependent Variable: tskdrp
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	16.93701	3.38740	41.43	<.0001
Error	13	1.06299	0.08177		
Corrected Total	18	18.00000			

Root MSE	0.28595	R-Square	0.9409
Dependent Mean	-8.6188E-16	Adj R-Sq	0.9182
Coeff Var	-3.31775E16		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-8.6188E-16	0.06560	-0.00	1.0000
car	1	0.71117	0.10110	7.03	<.0001
drd	1	0.34129	0.10110	3.38	0.0050
eei	1	0.34129	0.10110	3.38	0.0050
usp	1	1.17183	0.10110	11.59	<.0001
mrs	1	0.07229	0.10110	0.72	0.4872

SAS Results – P Values For Variable MRS.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
		Dependent Variable: tltt			
mrs	1	0.46996	0.25776	1.82	0.0913
		Dependent Variable: tlksa			
mrs	1	-0.08609	0.04221	-2.04	0.0623
		Dependent Variable: util			
mrs	1	-0.41098	0.15650	-2.63	**0.0209***
		Dependent Variable: noque			
mrs	1	-0.13047	0.07131	-1.83	0.0903
		Dependent Variable: tskint			
mrs	1	0.16577	0.22691	0.73	0.4780
		Dependent Variable: tsksup			
mrs	1	-0.33464	0.33925	-0.99	0.3419
		Dependent Variable: tskdrp			
mrs	1	0.07229	0.10110	0.72	0.4872

* The smallest P value is .0209 for the dependent variable UTIL. This value is therefore used as the threshold for significance to determine which of the independent variables will be used in the regression equation for each dependent variable.

Appendix G – Determination of Standardized Response Surface Maximum Values For Each DV.

Dependent Variable Taskload From Tasktime - TLTT.

The standardized regression equation for TLTT is:

TLTT = -0.91927USP -8.06370E-15

Taking the partial derivative of each independent variable gives:

$TLTT'_{USP}$ = -0.91927

Since there is only one equation and one unknown the result is determined by inspection:

USP = -0.91927

Dependent Variable Taskload From KSA - TLKSA.

The standardized regression equation for TLKSA is:

TLKSA = +1.48617USP -1.19310E-15

By inspection USP = 1.48617

Dependent Variable Utilization - UTIL.

The standardized regression equation for UTIL is:

UTIL = -0.71130CAR -0.64808DRD -0.90099USP -1.33020E-13

Taking the partial derivative of each independent variable gives:

$UTIL'_{CAR}$	= -0.71130	-0.64808DRD	-0.90099USP
$UTIL'_{DRD}$	= -0.71130CAR	-0.64808	-0.90099USP
$UTIL'_{USP}$	= -0.71130CAR	-0.64808DRD	-0.90099

Setting each partial derivative equal to zero gives:

-0.71130	-0.64808DRD	-0.90099USP	=	0
-0.71130CAR	-0.64808	-0.90099USP	=	0
-0.71130CAR	-0.64808DRD	-0.90099	=	0

Expressing these equations in matrix form and solving (MathSoft, 2001) for the 3 unknowns gives:

Taskload From Utilization - UTIL

$$M := \begin{pmatrix} 0 & -0.64808 & -0.90099 \\ -0.71130 & 0 & -0.90099 \\ -0.71130 & -0.64808 & 0 \end{pmatrix} \qquad v := \begin{pmatrix} 0.71130 \\ 0.64808 \\ 0.90099 \end{pmatrix}$$

$$soln := lsolve(M, v)$$

$$soln = \begin{pmatrix} -0.589 \\ -0.744 \\ -0.254 \end{pmatrix}$$

Determination of Maximum Regression Values For UTIL

Expressing the results back into equation form gives the maximum value in the response surface for each independent measure for the dependent measure UTIL:

CAR = -0.589
DRD = -0.744
USP = -0.254

Dependent Variable Number of Queues - NOQUE.

The standardized regression equation for NOQUE from Equations 6 is:

NOQUE = 0.96826CAR + 0.50875EEI +0.97401USP-2.46880E-16

Taking the partial derivative of each independent variable gives:

$$\begin{aligned} NOQUE'_{CAR} &= 0.96826 + 0.50875EEI + 0.97401USP \\ NOQUE'_{EEI} &= 0.96826CAR + 0.50875 + 0.97401USP \\ NOQUE'_{USP} &= 0.96826CAR + 0.50875EEI + 0.97401 \end{aligned}$$

Setting each partial derivative equal to zero gives:

$$\begin{aligned} 0.96826 + 0.50875EEI + 0.97401USP &= 0 \\ 0.96826CAR + 0.50875 + 0.97401USP &= 0 \\ 0.96826CAR + 0.50875EEI + 0.97401 &= 0 \end{aligned}$$

Expressing these equations in matrix form and solving (MathSoft, 2001) for the 4 unknowns gives:

Taskload From Number of Queues - NOQUE

$$M := \begin{pmatrix} 0 & 0.50875 & 0.97401 \\ 0.96826 & 0 & 0.97401 \\ 0.96826 & 0.50875 & 0 \end{pmatrix} \qquad v := \begin{pmatrix} -0.50875 \\ -0.50875 \\ -0.97401 \end{pmatrix}$$

$$soln := lsolve(M, v)$$

$$soln = \begin{pmatrix} -0.503 \\ -0.957 \\ -0.022 \end{pmatrix}$$

Determination of Maximum Regression Values For NOQUE

Expressing the results back into equation form gives the maximum value in the response surface for each independent measure for the dependent measure NOQUE:

CAR = -0.503
EEI = -0.957
USP = -0.022

Dependent Variable Number of Task Interrupts - TSKINT.

The standardized regression equation for TSKINT is:

TSKINT = +1.05569USP +3.21512E-14

By Inspection,

USP = 1.05569

Dependent Variable Number of Task Suspensions - TSKSUP.

The standardized regression equation for TSKSUP from Equations 6 is:

TSKSUP = + 2.03638E-15

This variable does not significantly respond to any of the IV's.

Dependent Variable Number of Task Drops - TSKDRP.

The standardized regression equation for TSKDRP from Equations 6 is:

TSKDRP =0.71117CAR+0.34129DRD+0.34129EEI +1.17183USP -8.61880E-16

Taking the partial derivative of each independent variable gives:

$$\begin{aligned}
TSKDRP'_{CAR} &= 0.71117 + 0.34129DRD + 0.34129EEI + 1.17183USP \\
TSKDRP'_{DRD} &= 0.71117CAR + 0.34129 + 0.34129EEI + 1.17183USP \\
TSKDRP'_{EEI} &= 0.71117CAR + 0.34129DRD + 0.34129 + 1.17183USP \\
TSKDRP'_{USP} &= 0.71117CAR + 0.34129DRD + 0.34129EEI + 1.17183
\end{aligned}$$

Setting each partial derivative equal to zero gives:

$$\begin{aligned}
0.71117 + 0.34129DRD + 0.34129EEI + 1.17183USP &= 0 \\
0.71117CAR + 0.34129 + 0.34129EEI + 1.17183USP &= 0 \\
0.71117CAR + 0.34129DRD + 0.34129 + 1.17183USP &= 0 \\
0.71117CAR + 0.34129DRD + 0.34129EEI + 1.17183 &= 0
\end{aligned}$$

Expressing these equations in matrix form and solving (MathSoft, 2001) for the 4 unknowns gives:

Taskload From Number of Tasks Dropped - TSKDRP

$$M := \begin{pmatrix} 0 & 0.34129 & 0.34129 & 1.17183 \\ 0.71117 & 0 & 0.34129 & 1.17183 \\ 0.71117 & 0.34129 & 0 & 1.17183 \\ 0.71117 & 0.34129 & 0.34129 & 0 \end{pmatrix} \qquad v := \begin{pmatrix} -0.71117 \\ -0.34129 \\ -0.34129 \\ -1.17183 \end{pmatrix}$$

$$soln := lsolve(M, v)$$

$$soln = \begin{pmatrix} -0.203 \\ -1.506 \\ -1.506 \\ 0.27 \end{pmatrix}$$

Determination of Maximum Regression Values For TSKDRP

Expressing the results back into equation form gives the maximum value in the response surface for each independent measure for the dependent measure TSKDRP:

CAR = -0.203
DRD = -1.506
EEI = -1.506
USP = 0.27

Appendix H – Determination of Significance of Main Effects for Each Dependent Variable.

SAS GLM for ANOVA Run – Original Data.

```
options pageno=1 formdlim='-';
  TITLE 'CoHOST 1/4 Replicate of 2**5 Design';
 DATA cohost;
 INPUT car drd eei usp mrs subj tltt tlksa util noque tskint tsksup tskdrp;
* Independent variables - Factors:;
*   Factor A:  CAR - Communicate and Report;
*   Factor B:  DRD - Decide and Recommend / Direct;
*   Factor C:  EEI - Evaluate and Estimate Impact;
*   Factor D:  USP - Identify / Understand Situational Picture;
*   Factor E:  MRS - Manage Resources;
*   Simulated subjects:  subj;
*;
* Dependent variables:;
*   TLTT - Taskload from Workload in the Task Time runs;
*   TLKSA - Taskload from Workload in the KSA / JASS data runs;
*   UTIL - % Utilization over run;
*   NOQUE - Number of queues generated during the run, ;
*           i.e., the number of times a task was queued up;
*   TSKINT - Number of times a task was interrupted;
*   TSKSUP - Number of times a task was suspended;
*   TSKDRP - Number of times a task was dropped;
*;
* Provide input data as CARDS statements ;
* 1/4 replicate portion:  ;
* 5 Factors - 2 levels/factor= 32 Treatment Combinations x    ;
*                               1 subject per cell =     ;
*                              32 Treatments if full factorial;
*                               8 Treatments for 1/4 fractional factorial;
* Central composite center point treatment:  ;
* 11 treatments on center point to provide 3rd treatment level;
*;
 CARDS;
1      -1     -1     -1     -1     1      39.275 31.884 0.9250 49.33  90.33  10.47  9.60
-1     1      1      -1     -1     1      40.084 32.625 0.9256 47.13  89.07  10.33  9.40
1      1      -1     1      -1     1      38.588 46.259 0.9213 55.13  88.47  10.47  14.20
-1     -1     1      1      -1     1      36.793 46.988 0.9242 51.73  88.47  10.67  12.20
-1     1      -1     -1     1      1      39.810 31.557 0.9242 42.80  90.87  10.40  8.93
1      -1     1      -1     1      1      39.439 32.952 0.9244 50.60  90.27  10.80  10.93
-1     -1     -1     1      1      1      39.217 45.920 0.9240 48.27  89.07  10.40  11.07
1      1      1      1      1      1      38.891 44.180 0.9183 58.47  87.27  9.47   15.33
0      0      0      0      0      1      39.439 39.439 0.9244 50.60  90.27  10.80  10.93
0      0      0      0      0      2      39.391 39.391 0.9240 49.87  90.47  10.60  11.13
0      0      0      0      0      3      39.372 39.372 0.9242 49.87  89.87  10.80  11.13
0      0      0      0      0      4      39.351 39.351 0.9243 49.53  90.13  10.93  10.53
0      0      0      0      0      5      39.407 39.407 0.9246 50.93  89.60  10.73  10.47
0      0      0      0      0      6      39.367 39.367 0.9244 49.67  89.60  10.80  10.93
0      0      0      0      0      7      39.320 39.320 0.9246 49.07  90.27  10.73  10.93
0      0      0      0      0      8      39.346 39.346 0.9239 49.73  89.87  10.87  10.60
0      0      0      0      0      9      40.207 40.207 0.9235 50.00  89.87  10.80  10.87
0      0      0      0      0      10     39.340 39.340 0.9238 50.07  89.67  10.73  11.20
0      0      0      0      0      11     39.382 39.382 0.9246 50.40  89.80  10.60  10.80
;
proc glm data=cohost;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Taskload from Task Time';
       class car drd eei usp mrs;
       model tltt = car drd eei usp mrs drd*eei drd*mrs;
run;
proc glm data=cohost;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Taskload from KSA Values';
       class car drd eei usp mrs;
       model tlksa = car drd eei usp mrs drd*eei drd*mrs;
run;
proc glm data=cohost;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Utilization';
       class car drd eei usp mrs;
       model util = car drd eei usp mrs drd*eei drd*mrs;
run;
```

```
proc glm data=cohost;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Number of Queues';
        class car drd eei usp mrs;
        model noque = car drd eei usp mrs drd*eei drd*mrs;
run;
proc glm data=cohost;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Task Interrupts';
        class car drd eei usp mrs;
        model tskint = car drd eei usp mrs drd*eei drd*mrs;
run;
proc glm data=cohost;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Task Suspensions';
        class car drd eei usp mrs;
        model tsksup = car drd eei usp mrs drd*eei drd*mrs;
run;
proc glm data=cohost;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Task Drops';
        class car drd eei usp mrs;
        model tskdrp = car drd eei usp mrs drd*eei drd*mrs;
run;
```

SAS GLM for ANOVA Run Output – Original Data.

```
-------------------------------------------------------------------------------------------
      Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Taskload from Task Time      1
                                                                  08:54 Thursday, June 21, 2001

                                The GLM Procedure
                           Class Level Information
                        Class         Levels    Values
                        car                3    -1 0 1
                        drd                3    -1 0 1
                        eei                3    -1 0 1
                        usp                3    -1 0 1
                        mrs                3    -1 0 1
                          Number of observations    19
-------------------------------------------------------------------------------------------
      Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Taskload from Task Time      2
                                                                  08:54 Thursday, June 21, 2001

                                The GLM Procedure
Dependent Variable: tltt

                                          Sum of
      Source                      DF       Squares     Mean Square    F Value    Pr > F
      Model                        8    8.07562780      1.00945347      15.63    0.0001
      Error                       10    0.64564273      0.06456427
      Corrected Total             18    8.72127053

                  R-Square     Coeff Var      Root MSE      tltt Mean
                  0.925969      0.647142      0.254095       39.26416

      Source                      DF      Type I SS     Mean Square    F Value    Pr > F
      car                          2    0.88817905      0.44408952       6.88    0.0132
      drd                          1    0.87715013      0.87715013      13.59    0.0042
      eei                          1    0.35406113      0.35406113       5.48    0.0412
      usp                          1    3.27552013      3.27552013      50.73    <.0001
      mrs                          1    0.85608612      0.85608612      13.26    0.0045
      drd*eei                      1    1.00607112      1.00607112      15.58    0.0027
      drd*mrs                      1    0.81856013      0.81856013      12.68    0.0052

      Source                      DF     Type III SS     Mean Square    F Value    Pr > F
      car                          1    0.01044012      0.01044012       0.16    0.6961
      drd                          1    0.87715013      0.87715013      13.59    0.0042
      eei                          1    0.35406113      0.35406113       5.48    0.0412
      usp                          1    3.27552013      3.27552013      50.73    <.0001
      mrs                          1    0.85608612      0.85608612      13.26    0.0045
      drd*eei                      1    1.00607112      1.00607112      15.58    0.0027
      drd*mrs                      1    0.81856013      0.81856013      12.68    0.0052
```

The GLM Procedure

Class Level Information

Class	Levels	Values
car	3	-1 0 1
drd	3	-1 0 1
eei	3	-1 0 1
usp	3	-1 0 1
mrs	3	-1 0 1

Number of observations 19

The GLM Procedure

Dependent Variable: tlksa

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	375.2058530	46.9007316	726.42	<.0001
Error	10	0.6456427	0.0645643		
Corrected Total	18	375.8514957			

R-Square	Coeff Var	Root MSE	tlksa Mean
0.998282	0.646910	0.254095	39.27826

Source	DF	Type I SS	Mean Square	F Value	Pr > F
car	2	1.1596252	0.5798126	8.98	0.0059
drd	1	1.2191411	1.2191411	18.88	0.0015
eei	1	0.1582031	0.1582031	2.45	0.1486
usp	1	368.9550301	368.9550301	5714.54	<.0001
mrs	1	1.2379511	1.2379511	19.17	0.0014
drd*eei	1	1.2379511	1.2379511	19.17	0.0014
drd*mrs	1	1.2379511	1.2379511	19.17	0.0014

Source	DF	Type III SS	Mean Square	F Value	Pr > F
car	1	0.4117781	0.4117781	6.38	0.0301
drd	1	1.2191411	1.2191411	18.88	0.0015
eei	1	0.1582031	0.1582031	2.45	0.1486
usp	1	368.9550301	368.9550301	5714.54	<.0001
mrs	1	1.2379511	1.2379511	19.17	0.0014
drd*eei	1	1.2379511	1.2379511	19.17	0.0014
drd*mrs	1	1.2379511	1.2379511	19.17	0.0014

The GLM Procedure

Class Level Information

Class	Levels	Values
car	3	-1 0 1
drd	3	-1 0 1
eei	3	-1 0 1
usp	3	-1 0 1
mrs	3	-1 0 1

Number of observations 19

The GLM Procedure

Dependent Variable: util

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	0.00004368	0.00000546	40.47	<.0001
Error	10	0.00000135	0.00000013		
Corrected Total	18	0.00004503			

R-Square	Coeff Var	Root MSE	util Mean
0.970038	0.039757	0.000367	0.923858

Source	DF	Type I SS	Mean Square	F Value	Pr > F
car	2	0.00001335	0.00000667	49.47	<.0001
drd	1	0.00000841	0.00000841	62.30	<.0001
eei	1	0.00000050	0.00000050	3.71	0.0831
usp	1	0.00001624	0.00001624	120.41	<.0001
mrs	1	0.00000338	0.00000338	25.05	0.0005
drd*eei	1	0.00000018	0.00000018	1.33	0.2749
drd*mrs	1	0.00000162	0.00000162	12.01	0.0061

Source	DF	Type III SS	Mean Square	F Value	Pr > F
car	1	0.00001013	0.00001013	75.05	<.0001
drd	1	0.00000841	0.00000841	62.30	<.0001
eei	1	0.00000050	0.00000050	3.71	0.0831
usp	1	0.00001624	0.00001624	120.41	<.0001
mrs	1	0.00000338	0.00000338	25.05	0.0005
drd*eei	1	0.00000018	0.00000018	1.33	0.2749
drd*mrs	1	0.00000162	0.00000162	12.01	0.0061

The GLM Procedure

Class Level Information

Class	Levels	Values
car	3	-1 0 1
drd	3	-1 0 1
eei	3	-1 0 1
usp	3	-1 0 1
mrs	3	-1 0 1

Number of observations 19

The GLM Procedure

Dependent Variable: noque

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	164.3965981	20.5495748	76.53	<.0001
Error	10	2.6850545	0.2685055		
Corrected Total	18	167.0816526			

R-Square	Coeff Var	Root MSE	noque Mean
0.983930	1.032871	0.518175	50.16842

Source	DF	Type I SS	Mean Square	F Value	Pr > F
car	2	70.58364809	35.29182404	131.44	<.0001
drd	1	1.62000000	1.62000000	6.03	0.0339
eei	1	19.22000000	19.22000000	71.58	<.0001
usp	1	70.44845000	70.44845000	262.37	<.0001
mrs	1	1.26405000	1.26405000	4.71	0.0552
drd*eei	1	1.08045000	1.08045000	4.02	0.0727
drd*mrs	1	0.18000000	0.18000000	0.67	0.4320

Source	DF	Type III SS	Mean Square	F Value	Pr > F
car	1	69.62000000	69.62000000	259.29	<.0001
drd	1	1.62000000	1.62000000	6.03	0.0339
eei	1	19.22000000	19.22000000	71.58	<.0001
usp	1	70.44845000	70.44845000	262.37	<.0001
mrs	1	1.26405000	1.26405000	4.71	0.0552
drd*eei	1	1.08045000	1.08045000	4.02	0.0727
drd*mrs	1	0.18000000	0.18000000	0.67	0.4320

The GLM Procedure

Class Level Information

Class	Levels	Values
car	3	-1 0 1
drd	3	-1 0 1
eei	3	-1 0 1
usp	3	-1 0 1
mrs	3	-1 0 1

Number of observations 19

The GLM Procedure

Dependent Variable: tskint

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	12.42864498	1.55358062	17.80	<.0001
Error	10	0.87261818	0.08726182		
Corrected Total	18	13.30126316			

R-Square	Coeff Var	Root MSE	tskint Mean
0.934396	0.329526	0.295401	89.64421

Source	DF	Type I SS	Mean Square	F Value	Pr > F
car	2	2.56194498	1.28097249	14.68	0.0011
drd	1	0.75645000	0.75645000	8.67	0.0147
eei	1	1.67445000	1.67445000	19.19	0.0014
usp	1	6.58845000	6.58845000	75.50	<.0001
mrs	1	0.16245000	0.16245000	1.86	0.2024
drd*eei	1	0.68445000	0.68445000	7.84	0.0188
drd*mrs	1	0.00045000	0.00045000	0.01	0.9442

Source	DF	Type III SS	Mean Square	F Value	Pr > F
car	1	0.16245000	0.16245000	1.86	0.2024
drd	1	0.75645000	0.75645000	8.67	0.0147
eei	1	1.67445000	1.67445000	19.19	0.0014
usp	1	6.58845000	6.58845000	75.50	<.0001
mrs	1	0.16245000	0.16245000	1.86	0.2024
drd*eei	1	0.68445000	0.68445000	7.84	0.0188
drd*mrs	1	0.00045000	0.00045000	0.01	0.9442

The GLM Procedure

Class Level Information

Class	Levels	Values
car	3	-1 0 1
drd	3	-1 0 1
eei	3	-1 0 1
usp	3	-1 0 1
mrs	3	-1 0 1

Number of observations 19

The GLM Procedure

Dependent Variable: tsksup

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	1.79978182	0.22497273	22.23	<.0001
Error	10	0.10121818	0.01012182		
Corrected Total	18	1.90100000			

R-Square	Coeff Var	Root MSE	tsksup Mean
0.946755	0.949125	0.100607	10.60000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
car	2	0.73530682	0.36765341	36.32	<.0001
drd	1	0.34861250	0.34861250	34.44	0.0002
eei	1	0.02761250	0.02761250	2.73	0.1296
usp	1	0.12251250	0.12251250	12.10	0.0059
mrs	1	0.09461250	0.09461250	9.35	0.0121
drd*eei	1	0.34861250	0.34861250	34.44	0.0002
drd*mrs	1	0.12251250	0.12251250	12.10	0.0059

Source	DF	Type III SS	Mean Square	F Value	Pr > F
car	1	0.04351250	0.04351250	4.30	0.0649
drd	1	0.34861250	0.34861250	34.44	0.0002
eei	1	0.02761250	0.02761250	2.73	0.1296
usp	1	0.12251250	0.12251250	12.10	0.0059
mrs	1	0.09461250	0.09461250	9.35	0.0121
drd*eei	1	0.34861250	0.34861250	34.44	0.0002
drd*mrs	1	0.12251250	0.12251250	12.10	0.0059

The GLM Procedure

Class Level Information

Class	Levels	Values
car	3	-1 0 1
drd	3	-1 0 1
eei	3	-1 0 1
usp	3	-1 0 1
mrs	3	-1 0 1

Number of observations 19

The GLM Procedure

Dependent Variable: tskdrp

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	39.19260096	4.89907512	80.57	<.0001
Error	10	0.60807273	0.06080727		
Corrected Total	18	39.80067368			

R-Square	Coeff Var	Root MSE	tskdrp Mean
0.984722	2.218598	0.246591	11.11474

Source	DF	Type I SS	Mean Square	F Value	Pr > F
car	2	10.56990096	5.28495048	86.91	<.0001
drd	1	2.06045000	2.06045000	33.88	0.0002
eei	1	2.06045000	2.06045000	33.88	0.0002
usp	1	24.29045000	24.29045000	399.47	<.0001
mrs	1	0.09245000	0.09245000	1.52	0.2458
drd*eei	1	0.09245000	0.09245000	1.52	0.2458
drd*mrs	1	0.02645000	0.02645000	0.43	0.5245

Source	DF	Type III SS	Mean Square	F Value	Pr > F
car	1	8.94645000	8.94645000	147.13	<.0001
drd	1	2.06045000	2.06045000	33.88	0.0002
eei	1	2.06045000	2.06045000	33.88	0.0002
usp	1	24.29045000	24.29045000	399.47	<.0001
mrs	1	0.09245000	0.09245000	1.52	0.2458
drd*eei	1	0.09245000	0.09245000	1.52	0.2458
drd*mrs	1	0.02645000	0.02645000	0.43	0.5245

SAS GLM for ANOVA Run – Standardized Data.

```
options pageno=1 formdlim='-';
  TITLE 'CoHOST 1/4 Replicate of 2**5 Design';
 DATA cohost;
 INPUT car drd eei usp mrs subj tltt tlksa util noque tskint tsksup tskdrp;
* Independent variables - Factors:;
*   Factor A:  CAR - Communicate and Report;
*   Factor B:  DRD - Decide and Recommend / Direct;
*   Factor C:  EEI - Evaluate and Estimate Impact;
*   Factor D:  USP - Identify / Understand Situational Picture;
*   Factor E:  MRS - Manage Resources;
*   Simulated subjects:  subj;
*;
* Dependent variables:;
*   TLTT - Taskload from Workload in the Task Time runs;
*   TLKSA - Taskload from Workload in the KSA / JASS data runs;
*   UTIL - % Utilization over run;
*   NOQUE - Number of queues generated during the run, ;
*           i.e., the number of times a task was queued up;
*   TSKINT - Number of times a task was interrupted;
*   TSKSUP - Number of times a task was suspended;
*   TSKDRP - Number of times a task was dropped;
*;
* Provide input data as CARDS statements ;
* 1/4 replicate portion:  ;
* 5 Factors - 2 levels/factor= 32 Treatment Combinations x    ;
*                               1 subject per cell =     ;
*                              32 Treatments if full factorial;
*                               8 Treatments for 1/4 fractional factorial;
* Central composite center point treatment:  ;
* 11 treatments on center point to provide 3rd treatment level;
*;
 CARDS;
1      -1     -1     -1     -1     1      39.275 31.884 0.9250 49.33  90.33  10.47  9.60
-1     1      1      -1     -1     1      40.084 32.625 0.9256 47.13  89.07  10.33  9.40
1      1      -1     1      -1     1      38.588 46.259 0.9213 55.13  88.47  10.47  14.20
-1     -1     1      1      -1     1      36.793 46.988 0.9242 51.73  88.47  10.67  12.20
-1     1      -1     -1     1      1      39.810 31.557 0.9242 42.80  90.87  10.40  8.93
1      -1     1      -1     1      1      39.439 32.952 0.9244 50.60  90.27  10.80  10.93
-1     -1     -1     1      1      1      39.217 45.920 0.9240 48.27  89.07  10.40  11.07
1      1      1      1      1      1      38.891 44.180 0.9183 58.47  87.27  9.47   15.33
0      0      0      0      0      1      39.439 39.439 0.9244 50.60  90.27  10.80  10.93
0      0      0      0      0      2      39.391 39.391 0.9240 49.87  90.47  10.60  11.13
0      0      0      0      0      3      39.372 39.372 0.9242 49.87  89.87  10.80  11.13
0      0      0      0      0      4      39.351 39.351 0.9243 49.53  90.13  10.93  10.53
0      0      0      0      0      5      39.407 39.407 0.9246 50.93  89.60  10.73  10.47
0      0      0      0      0      6      39.367 39.367 0.9244 49.67  89.60  10.80  10.93
0      0      0      0      0      7      39.320 39.320 0.9246 49.07  90.27  10.73  10.93
0      0      0      0      0      8      39.346 39.346 0.9239 49.73  89.87  10.87  10.60
0      0      0      0      0      9      40.207 40.207 0.9235 50.00  89.87  10.80  10.87
0      0      0      0      0      10     39.340 39.340 0.9238 50.07  89.67  10.73  11.20
0      0      0      0      0      11     39.382 39.382 0.9246 50.40  89.80  10.60  10.80
;
```

```
*;
*;
*  Standardize the data and rerun;
 options pageno=1 formdlim='-';
proc standard mean=0 std=1 out=cohosts data=cohost;
       var tltt tlksa util noque tskint tsksup tskdrp;
run;
*  ANOVA Runs:  ;
proc glm data=cohosts;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Taskload from Task Time';
       class car drd eei usp;
       model tltt = car drd eei usp;
run;
proc glm data=cohosts;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Taskload from KSA Values';
       class car drd eei usp;
       model tlksa = car drd eei usp;
run;
proc glm data=cohosts;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Utilization';
       class car drd eei usp;
       model util = car drd eei usp;
run;
proc glm data=cohosts;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Number of Queues';
       class car drd eei usp;
       model noque = car drd eei usp;
run;
proc glm data=cohosts;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Task Interrupts';
       class car drd eei usp;
       model tskint = car drd eei usp;
run;
proc glm data=cohosts;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Task Suspensions';
       class car drd eei usp;
       model tsksup = car drd eei usp;
run;
proc glm data=cohosts;
  TITLE 'Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Task Drops';
       class car drd eei usp;
       model tskdrp = car drd eei usp;
run;
```

SAS GLM for ANOVA Run Output – Standardized Data.

Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Taskload from Task Time 1
11:07 Thursday, July 5, 2001

The GLM Procedure

Class Level Information

Class	Levels	Values
car	3	-1 0 1
drd	3	-1 0 1
eei	3	-1 0 1
usp	3	-1 0 1

Number of observations 19

Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Taskload from Task Time 2
11:07 Thursday, July 5, 2001

The GLM Procedure

Dependent Variable: tltt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	11.13466064	2.22693213	4.22	0.0169
Error	13	6.86533936	0.52810303		
Corrected Total	18	18.00000000			

R-Square	Coeff Var	Root MSE	tltt Mean
0.618592	-8.9777E15	0.726707	-0.000000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
car	2	1.83313003	0.91656501	1.74	0.2147
drd	1	1.81036722	1.81036722	3.43	0.0869
eei	1	0.73075365	0.73075365	1.38	0.2606
usp	1	6.76040974	6.76040974	12.80	0.0034

Source	DF	Type III SS	Mean Square	F Value	Pr > F
car	1	0.02154758	0.02154758	0.04	**0.8430**
drd	1	1.81036722	1.81036722	3.43	**0.0869**
eei	1	0.73075365	0.73075365	1.38	**0.2606**
usp	1	6.76040974	6.76040974	12.80	**0.0034**

The GLM Procedure

Class Level Information

Class	Levels	Values
car	3	-1 0 1
drd	3	-1 0 1
eei	3	-1 0 1
usp	3	-1 0 1

Number of observations 19

The GLM Procedure

Dependent Variable: tlksa

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	17.79121826	3.55824365	221.56	<.0001
Error	13	0.20878174	0.01606013		
Corrected Total	18	18.00000000			

R-Square	Coeff Var	Root MSE	tlksa Mean
0.988401	-9.2683E15	0.126729	-0.000000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
car	2	0.05553591	0.02776795	1.73	0.2159
drd	1	0.05838620	0.05838620	3.64	0.0789
eei	1	0.00757655	0.00757655	0.47	0.5042
usp	1	17.66971961	17.66971961	1100.22	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
car	1	0.01972057	0.01972057	1.23	**0.2879**
drd	1	0.05838620	0.05838620	3.64	**0.0789**
eei	1	0.00757655	0.00757655	0.47	**0.5042**
usp	1	17.66971961	17.66971961	1100.22	**<.0001**

The GLM Procedure

Class Level Information

Class	Levels	Values
car	3	-1 0 1
drd	3	-1 0 1
eei	3	-1 0 1
usp	3	-1 0 1

Number of observations 19

The GLM Procedure

Dependent Variable: util

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	15.38989002	3.07797800	15.33	<.0001
Error	13	2.61010998	0.20077769		
Corrected Total	18	18.00000000			

R-Square	Coeff Var	Root MSE	util Mean
0.854994	-3.3694E14	0.448082	-0.000000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
car	2	5.33576962	2.66788481	13.29	0.0007
drd	1	3.36003507	3.36003507	16.74	0.0013
eei	1	0.19988311	0.19988311	1.00	0.3366
usp	1	6.49420222	6.49420222	32.35	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
car	1	4.04763296	4.04763296	20.16	**0.0006**
drd	1	3.36003507	3.36003507	16.74	**0.0013**
eei	1	0.19988311	0.19988311	1.00	**0.3366**
usp	1	6.49420222	6.49420222	32.35	**<.0001**

Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Number of Queues 7
11:07 Thursday, July 5, 2001

The GLM Procedure

Class Level Information

Class	Levels	Values
car	3	-1 0 1
drd	3	-1 0 1
eei	3	-1 0 1
usp	3	-1 0 1

Number of observations 19

Augmented 1/4 Replicate of 2**5 Design on COHOST Simulation - Number of Queues 8
11:07 Thursday, July 5, 2001

The GLM Procedure

Dependent Variable: noque

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	17.43876554	3.48775311	80.79	<.0001
Error	13	0.56123446	0.04317188		
Corrected Total	18	18.00000000			

R-Square	Coeff Var	Root MSE	noque Mean
0.968820	-7.9907E16	0.207778	-0.000000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
car	2	7.60410042	3.80205021	88.07	<.0001
drd	1	0.17452545	0.17452545	4.04	0.0656
eei	1	2.07060437	2.07060437	47.96	<.0001
usp	1	7.58953530	7.58953530	175.80	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
car	1	7.50028492	7.50028492	173.73	<.0001
drd	1	0.17452545	0.17452545	4.04	0.0656
eei	1	2.07060437	2.07060437	47.96	<.0001
usp	1	7.58953530	7.58953530	175.80	<.0001

The GLM Procedure

Class Level Information

Class	Levels	Values
car	3	-1 0 1
drd	3	-1 0 1
eei	3	-1 0 1
usp	3	-1 0 1

Number of observations 19

The GLM Procedure

Dependent Variable: tskint

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	15.67244457	3.13448891	17.51	<.0001
Error	13	2.32755543	0.17904273		
Corrected Total	18	18.00000000			

R-Square	Coeff Var	Root MSE	tskint Mean
0.870691	1.30593E15	0.423134	3.2401E-14

Source	DF	Type I SS	Mean Square	F Value	Pr > F
car	2	3.46696468	1.73348234	9.68	0.0027
drd	1	1.02366970	1.02366970	5.72	0.0326
eei	1	2.26595772	2.26595772	12.66	0.0035
usp	1	8.91585247	8.91585247	49.80	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
car	1	0.21983626	0.21983626	1.23	**0.2879**
drd	1	1.02366970	1.02366970	5.72	**0.0326**
eei	1	2.26595772	2.26595772	12.66	**0.0035**
usp	1	8.91585247	8.91585247	49.80	**<.0001**

The GLM Procedure

Class Level Information

Class	Levels	Values
car	3	-1 0 1
drd	3	-1 0 1
eei	3	-1 0 1
usp	3	-1 0 1

Number of observations 19

The GLM Procedure

Dependent Variable: tsksup

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	11.68479628	2.33695926	4.81	0.0104
Error	13	6.31520372	0.48578490		
Corrected Total	18	18.00000000			

R-Square	Coeff Var	Root MSE	tsksup Mean
0.649155	3.37424E16	0.696983	2.0656E-15

Source	DF	Type I SS	Mean Square	F Value	Pr > F
car	2	6.96240017	3.48120009	7.17	0.0080
drd	1	3.30090742	3.30090742	6.79	0.0217
eei	1	0.26145450	0.26145450	0.54	0.4762
usp	1	1.16003419	1.16003419	2.39	0.1463

Source	DF	Type III SS	Mean Square	F Value	Pr > F
car	1	0.41200684	0.41200684	0.85	**0.3739**
drd	1	3.30090742	3.30090742	6.79	**0.0217**
eei	1	0.26145450	0.26145450	0.54	**0.4762**
usp	1	1.16003419	1.16003419	2.39	**0.1463**

The GLM Procedure

Class Level Information

Class	Levels	Values
car	3	-1 0 1
drd	3	-1 0 1
eei	3	-1 0 1
usp	3	-1 0 1

Number of observations 19

The GLM Procedure

Dependent Variable: tskdrp

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	17.62941308	3.52588262	123.69	<.0001
Error	13	0.37058692	0.02850669		
Corrected Total	18	18.00000000			

R-Square	Coeff Var	Root MSE	tskdrp Mean
0.979412	-2.2932E16	0.168839	-0.000000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
car	2	4.78027630	2.39013815	83.84	<.0001
drd	1	0.93184604	0.93184604	32.69	<.0001
eei	1	0.93184604	0.93184604	32.69	<.0001
usp	1	10.98544471	10.98544471	385.36	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
car	1	4.04606468	4.04606468	141.93	<.0001
drd	1	0.93184604	0.93184604	32.69	<.0001
eei	1	0.93184604	0.93184604	32.69	<.0001
usp	1	10.98544471	10.98544471	385.36	<.0001

Appendix I – Determination of Significance of LOF And Regression For Each DV.

As previously discussed, only the main effects of each treatment factor are of interest in this experimental design for each dependent variable, however, whether or not each main effect has a higher order response is also of interest. In order to determine this the Lack of Fit (LOF) for each dependent variable is examined for significance. If the test for significance is positive then that effect is predicted to have at least a quadratic component which can then be examined with a response surface analysis. The Type III sum of squares results from the PROC GLM tests in appendix H will be used for this LOF significance test. The procedure consists of first summing the Type III sum of squares for the main effect factors CAR, DRD, EEI, USP, and MRS. The LOF sum of squares (SS) is calculated by subtracting the $SS_{MAIN\ EFFECTS}$ from the SS_{MODEL} to product the SS_{LOF}. The mean square for the LOF (MS_{LOF}) is then calculated by dividing SS_{LOF} by the degrees of freedom for the LOF which is 3 as shown in the regression summary table at Table 7. The F Ratio is then calculated by dividing the MS_{LOF} by the mean square error term from the GLM output.

This produces the observed value for the F ratio ($F_{observed\text{-}LOF}$) which is compared to a tabled value for the F ratio to determine significance of the LOF. The numerator for the tabled value is the 3 degrees of freedom for LOF from Table 7, and the denominator is the 10 degrees of freedom for the Error term also from Table 7 and from the GLM run. Looking this up in an appropriate F table (Winer et al., 1991) (p. 968) produces a tabled value for the F ratio of 6.55 at the .01 level (the $\alpha = .01$ level is used as a result of the significance threshold determined from the MRS variable). This process is illustrated in Table 23 using the dependent variable TLTT as an example. The calculations and significance tests for all the dependent variables is at appendix I. The table below summarizes the LOF significance tests for the dependent variables. The test results in this table indicate that only one dependent variable, NOQUE, failed the LOF test indicating that it is predicted to have only a linear response. The other six variables, TLTT, TLKSA, UTIL, TSKINT, TSKSUP, and TSKDRP are all predicted to have at least a quadratic component in their response to the independent variables.

LOF For Dependent Variable Taskload from Task Time (TLTT).

LOF Calculation for Taskload from Task Time:						
		The GLM Procedure				
Dependent	Variable:	tltt				
			Sum of			
	Source	DF	Squares	Mean Square	F Value	Pr > F
	Model	8	8.0756278	1.00945347	15.63	0.0001
	Error	10	0.64564273	0.06456427		
	Corrected Total	18	8.72127053			
	Source	DF	Type III SS	Mean Square	F Value	Pr > F
	car	1	0.01044012	0.01044012	0.16	0.6961
	drd	1	0.87715013	0.87715013	13.59	0.0042
	eei	1	0.35406113	0.35406113	5.48	0.0412
	usp	1	3.27552013	3.27552013	50.73	<.0001
	mrs	1	0.85608612	0.85608612	13.26	0.0045
	Sum (IV's) =		5.37325763			
	LOF = SS(model) - Sum SS(IV's) =	3	2.70237017	0.90079006	13.952	
	Decision Rule:					
	H_0: $\sigma_A^2 = 0$					
	H_1: $\sigma_A^2 \neq 0$					
	$\alpha = .05$					
	D.R.: I reject H_0 if $\lvert F_{observed} \rvert > \lvert F_{tabled} \rvert$					
	$F_{observed\text{-}LOF\text{-}TLTT}$ =				13.952	
	* $F_{tabled\text{-}LOF} = F_{(3,10)}$ =				6.55	
	* Winer, p. 968 @ .01 level (1-alpha=.99)					
	∴ Reject H_0 with the result that LOF for TLTT is significant.					

LOF For Dependent Variable Taskload from KSA (TLKSA).

LOF Calculation for Taskload from KSA:						
		The GLM Procedure				
Dependent	Variable:	tlksa				
			Sum of			
	Source	DF	Squares	Mean Square	F Value	Pr > F
	Model	8	375.205853	46.9007316	726.42	<.0001
	Error	10	0.6456427	0.0645643		
	Corrected Total	18	375.8514957			
	Source	DF	Type III SS	Mean Square	F Value	Pr > F
	car	1	0.4117781	0.4117781	6.38	0.0301
	drd	1	1.2191411	1.2191411	18.88	0.0015
	eei	1	0.1582031	0.1582031	2.45	0.1486
	usp	1	368.9550301	368.9550301	5714.54	<.0001
	mrs	1	1.2379511	1.2379511	19.17	0.0014
	Sum (IV's) =		371.982104			
	LOF = SS(model) - Sum SS(IV's) =	3	3.2237495	1.07458317	16.644	
	Decision Rule:					
	H_0: $\sigma_A^2 = 0$					
	H_1: $\sigma_A^2 \neq 0$					
	$\alpha = .05$					
	D.R.: I reject H_0 if $\lvert F_{observed} \rvert > \lvert F_{tabled} \rvert$					
	$F_{observed\text{-}LOF\text{-}TLKSA}$ =				16.644	
	* $F_{tabled\text{-}LOF} = F_{(3,10)}$ =				6.55	
	* Winer, p. 968 @ .01 level (1-alpha=.99)					
	∴ Reject H_0 with the result that LOF for TLKSA is significant.					

LOF For Dependent Variable Utilization (UTIL).

LOF Calculation for Utilization:						
		The GLM Procedure				
Dependent	Variable:	util				
			Sum of			
	Source	DF	Squares	Mean Square	F Value	Pr > F
	Model	8	0.00004368	0.00000546	40.47	<.0001
	Error	10	0.00000135	0.00000013		
	Corrected Total	18	0.00004503			
	Source	DF	Type III SS	Mean Square	F Value	Pr > F
	car	1	0.00001013	0.00001013	75.05	<.0001
	drd	1	0.00000841	0.00000841	62.3	<.0001
	eei	1	0.0000005	0.0000005	3.71	0.0831
	usp	1	0.00001624	0.00001624	120.41	<.0001
	mrs	1	0.00000338	0.00000338	25.05	0.0005
	Sum (IV's) =		0.00003866			
	LOF = SS(model) - Sum SS(IV's) =	3	0.00000502	1.6733E-06	12.872	
	Decision Rule:					
	H_0: $\sigma_A^2 = 0$					
	H_1: $\sigma_A^2 \neq 0$					
	$\alpha = .05$					
	D.R.: I reject H_0 if $\lvert F_{observed} \rvert > \lvert F_{tabled} \rvert$					
	$F_{observed\text{-}LOF\text{-}UTIL}$ =				12.872	
	* $F_{tabled\text{-}LOF} = F_{(3,10)}$ =				6.55	
	* Winer, p. 968 @ .01 level (1-alpha=.99)					
	∴ Reject H_0 with the result that LOF for UTIL is significant.					

LOF For Dependent Variable Number of Queues (NOQUE).

LOF Calculation for Number of Queues:						
		The GLM Procedure				
Dependent	Variable:	noque				
			Sum of			
	Source	DF	Squares	Mean Square	F Value	Pr > F
	Model	8	164.3965981	20.5495748	76.53	<.0001
	Error	10	2.6850545	0.2685055		
	Corrected Total	18	167.0816526			
	Source	DF	Type III SS	Mean Square	F Value	Pr > F
	car	1	69.62	69.62	259.29	<.0001
	drd	1	1.62	1.62	6.03	0.0339
	eei	1	19.22	19.22	71.58	<.0001
	usp	1	70.44845	70.44845	262.37	<.0001
	mrs	1	1.26405	1.26405	4.71	0.0552
	Sum (IV's) =		162.1725			
	LOF = SS(model) - Sum SS(IV's) =	3	2.2240981	0.74136603	2.7611	
	Decision Rule:					
	H_0: $\sigma_A^2 = 0$					
	H_1: $\sigma_A^2 \neq 0$					
	$\alpha = .05$					
	D.R.: I reject H_0 if $\lvert F_{observed} \rvert > \lvert F_{tabled} \rvert$					
	$F_{observed\text{-}LOF\text{-}NOQUE}$ =				2.7611	
	* $F_{tabled\text{-}LOF} = F_{(3,10)}$ =				6.55	
	* Winer, p. 968 @ .01 level (1-alpha=.99)					
	∴ Fail to Reject H_0 with the result that LOF for NOQUE is NOT significant.					

LOF For Dependent Variable Number of Task Interrupts (TSKINT).

LOF Calculation for Number of Tasks Interrupted:						
		The GLM Procedure				
Dependent	Variable:	tskint				
			Sum of			
	Source	DF	Squares	Mean Square	F Value	Pr > F
	Model	8	12.42864498	1.55358062	17.8	<.0001
	Error	10	0.87261818	0.08726182		
	Corrected Total	18	13.30126316			
	Source	DF	Type III SS	Mean Square	F Value	Pr > F
	car	1	0.16245	0.16245	1.86	0.2024
	drd	1	0.75645	0.75645	8.67	0.0147
	eei	1	1.67445	1.67445	19.19	0.0014
	usp	1	6.58845	6.58845	75.5	<.0001
	mrs	1	0.16245	0.16245	1.86	0.2024
	Sum (IV's) =		9.34425			
	LOF = SS(model) - Sum SS(IV's) =	3	3.08439498	1.02813166	11.782	
	Decision Rule:					
	H_0: $\sigma_A^2 = 0$					
	H_1: $\sigma_A^2 \neq 0$					
	$\alpha = .05$					
	D.R.: I reject H_0 if $\lvert F_{observed} \rvert > \lvert F_{tabled} \rvert$					
	$F_{observed\text{-}LOF\text{-}TSKINT}$ =				11.782	
	* $F_{tabled\text{-}LOF} = F_{(3,10)}$ =				6.55	
	* Winer, p. 968 @ .01 level (1-alpha=.99)					
	∴ Reject H_0 with the result that LOF for TSKINT is significant.					

LOF For Dependent Variable Number of Task Suspensions (TSKSUP).

LOF Calculation for Number of Tasks Suspended:						
		The GLM Procedure				
Dependent	Variable:	tsksup				
			Sum of			
	Source	DF	Squares	Mean Square	F Value	Pr > F
	Model	8	1.79978182	0.22497273	22.23	<.0001
	Error	10	0.10121818	0.01012182		
	Corrected Total	18	1.901			
	Source	DF	Type III SS	Mean Square	F Value	Pr > F
	car	1	0.0435125	0.0435125	4.3	0.0649
	drd	1	0.3486125	0.3486125	34.44	0.0002
	eei	1	0.0276125	0.0276125	2.73	0.1296
	usp	1	0.1225125	0.1225125	12.1	0.0059
	mrs	1	0.0946125	0.0946125	9.35	0.0121
	Sum (IV's) =		0.6368625			
	LOF = SS(model) - Sum SS(IV's) =	3	1.16291932	0.38763977	38.297	
	Decision Rule:					
	H_0: $\sigma_A^2 = 0$					
	H_1: $\sigma_A^2 \neq 0$					
	$\alpha = .05$					
	D.R.: I reject H_0 if $\lvert F_{observed} \rvert > \lvert F_{tabled} \rvert$					
	$F_{observed\text{-}LOF\text{-}TSKSUP} =$				38.297	
	* $F_{tabled\text{-}LOF} = F_{(3,10)} =$				6.55	
	* Winer, p. 968 @ .01 level (1-alpha=.99)					
	∴ Reject H_0 with the result that LOF for TSKSUP is significant.					

LOF For Dependent Variable Number of Task Drops (TSKDRP).

LOF Calculation for Number of Tasks Dropped:						
		The GLM Procedure				
Dependent	Variable:	tskdrp				
			Sum of			
	Source	DF	Squares	Mean Square	F Value	Pr > F
	Model	8	39.19260096	4.89907512	80.57	<.0001
	Error	10	0.60807273	0.06080727		
	Corrected Total	18	39.80067368			
	Source	DF	Type III SS	Mean Square	F Value	Pr > F
	car	1	8.94645	8.94645	147.13	<.0001
	drd	1	2.06045	2.06045	33.88	0.0002
	eei	1	2.06045	2.06045	33.88	0.0002
	usp	1	24.29045	24.29045	399.47	<.0001
	mrs	1	0.09245	0.09245	1.52	0.2458
	Sum (IV's) =		37.45025			
	LOF = SS(model) - Sum SS(IV's) =	3	1.74235096	0.58078365	9.5512	
	Decision Rule:					
	H_0: $\sigma_A^2 = 0$					
	H_1: $\sigma_A^2 \neq 0$					
	$\alpha = .05$					
	D.R.: I reject H_0 if $\lvert F_{observed} \rvert > \lvert F_{tabled} \rvert$					
	$F_{observed\text{-}LOF\text{-}TSKDRP}$ =				9.5512	
	* $F_{tabled\text{-}LOF} = F_{(3,10)}$ =				6.55	
	* Winer, p. 968 @ .01 level (1-alpha=.99)					
	∴ Reject H_0 with the result that LOF for TSKDRP is significant.					

Regression ANOVA For Dependent Variable Taskload from Task Time (TLTT).

From the Regression Model ANOVA summary table design presented in Table 7, the results of statistical tests performed to establish the significance of each dependent variable to each independent variable is presented in Regression ANOVA tables. The determination of significance for LOF is determined by a manual evaluation using a decision rule and comparing a tabled F ratio to the observed F ratio as calculated.

Regression ANOVA Summary Table				
Augmented 1-4 Replicate 2-5 Design				
	Alternative Regression ANOVA			
Number of center point treatments, n(cp) =		11		
Number of Data Points That Have Repeated Observations				
(T) (i.e., the replication of the Center Point) =		1		
Treatment Combinations, N (n(1/4) + n(cp) x T) =		19		
Source	**df**	**MS**	**F**	**P**
Regression	(5)			
CAR	1	0.010	0.160	0.696
DRD	1	0.877	13.590	0.004
EEI	1	0.354	5.480	0.041
USP	1	3.276	50.730	<.0001
MRS	1	0.856	13.260	0.005
Residuals	(13)			
Lack Of Fit (LOF)	3	0.901	13.952	*Significant
Error ((n(cp) -1) x T)	10	0.065		
Total:	(18)			
Verification: N-1 =	18			

* From manual decision rule test.

Regression ANOVA For Dependent Variable Taskload from KSA (TLKSA).

Regression ANOVA Summary Table				
Augmented 1-4 Replicate 2-5 Design				
	Alternative Regression ANOVA			
Number of center point treatments, n(cp) =		11		
Number of Data Points That Have Repeated Observations				
(T) (i.e., the replication of the Center Point) =		1		
Treatment Combinations, N (n(1/4) + n(cp) x T) =		19		
Source	**df**	**MS**	**F**	**P**
Regression	(5)			
CAR	1	0.412	6.380	0.030
DRD	1	1.219	18.880	0.002
EEI	1	0.158	2.450	0.149
USP	1	368.955	5714.540	<.0001
MRS	1	1.238	19.170	0.001
Residuals	(13)			
Lack Of Fit (LOF)	3	1.075	16.644	*Significant
Error ((n(cp) -1) x T)	10	0.065		
Total:	(18)			
Verification: N-1 =	18			

* From manual decision rule test.

Regression ANOVA For Dependent Variable Utilization (UTIL).

Regression ANOVA Summary Table				
Augmented 1-4 Replicate 2-5 Design				
	Alternative Regression ANOVA			
Number of center point treatments, n(cp) =		11		
Number of Data Points That Have Repeated Observations				
(T) (i.e., the replication of the Center Point) =		1		
Treatment Combinations, N (n(1/4) + n(cp) x T) =		19		
Source	**df**	**MS**	**F**	**P**
Regression	(5)			
CAR	1	0.00001013	75.050	<.0001
DRD	1	0.00000841	62.300	<.0001
EEI	1	0.00000050	3.710	0.083
USP	1	0.00001624	120.410	<.0001
MRS	1	0.00000338	25.050	0.001
Residuals	(13)			
Lack Of Fit (LOF)	3	0.00000167	12.872	*Significant
Error ((n(cp) -1) x T)	10	0.00004503		
Total:	(18)			
Verification: N-1 =	18			

* From manual decision rule test.

Regression ANOVA For Dependent Variable Number of Queues (NOQUE).

Regression ANOVA Summary Table				
Augmented 1-4 Replicate 2-5 Design				
	Alternative Regression ANOVA			
Number of center point treatments, n(cp) =		11		
Number of Data Points That Have Repeated Observations				
(T) (i.e., the replication of the Center Point) =		1		
Treatment Combinations, N (n(1/4) + n(cp) x T) =		19		
Source	**df**	**MS**	**F**	**P**
Regression	(5)			
CAR	1	69.620	259.290	<.0001
DRD	1	1.620	6.030	0.034
EEI	1	19.220	71.580	<.0001
USP	1	70.448	262.370	<.0001
MRS	1	1.264	4.710	0.055
Residuals	(13)			
Lack Of Fit (LOF)	3	0.741	2.761	*Not Significant
Error ((n(cp) -1) x T)	10	2.685		
Total:	(18)			
Verification: N-1 =	18			

* From manual decision rule test.

Regression ANOVA For Dependent Variable Number of Task Interrupts (TSKINT).

Regression ANOVA Summary Table				
Augmented 1-4 Replicate 2-5 Design				
	Alternative Regression ANOVA			
Number of center point treatments, n(cp) =		11		
Number of Data Points That Have Repeated Observations				
(T) (i.e., the replication of the Center Point) =		1		
Treatment Combinations, N (n(1/4) + n(cp) x T) =		19		
Source	**df**	**MS**	**F**	**P**
Regression	(5)			
CAR	1	0.162	1.860	0.202
DRD	1	0.756	8.670	0.015
EEI	1	1.674	19.190	0.001
USP	1	6.588	75.500	<.0001
MRS	1	0.162	1.860	0.202
Residuals	(13)			
Lack Of Fit (LOF)	3	1.028	11.782	*Significant
Error ((n(cp) -1) x T)	10	0.873		
Total:	(18)			
Verification: N-1 =	18			

* From manual decision rule test.

Regression ANOVA For Dependent Variable Number of Task Suspensions (TSKSUP).

Regression ANOVA Summary Table				
Augmented 1-4 Replicate 2-5 Design				
	Alternative Regression ANOVA			
Number of center point treatments, n(cp) =		11		
Number of Data Points That Have Repeated Observations				
(T) (i.e., the replication of the Center Point) =		1		
Treatment Combinations, N (n(1/4) + n(cp) x T) =		19		
Source	**df**	**MS**	**F**	**P**
Regression	(5)			
CAR	1	0.044	4.300	0.065
DRD	1	0.349	34.440	0.000
EEI	1	0.028	2.730	0.130
USP	1	0.123	12.100	0.006
MRS	1	0.095	9.350	0.012
Residuals	(13)			
Lack Of Fit (LOF)	3	0.388	38.297	*Significant
Error ((n(cp) -1) x T)	10	0.010		
Total:	(18)			
Verification: N-1 =	18			

* From manual decision rule test.

Regression ANOVA For Dependent Variable Number of Task Drops (TSKDRP).

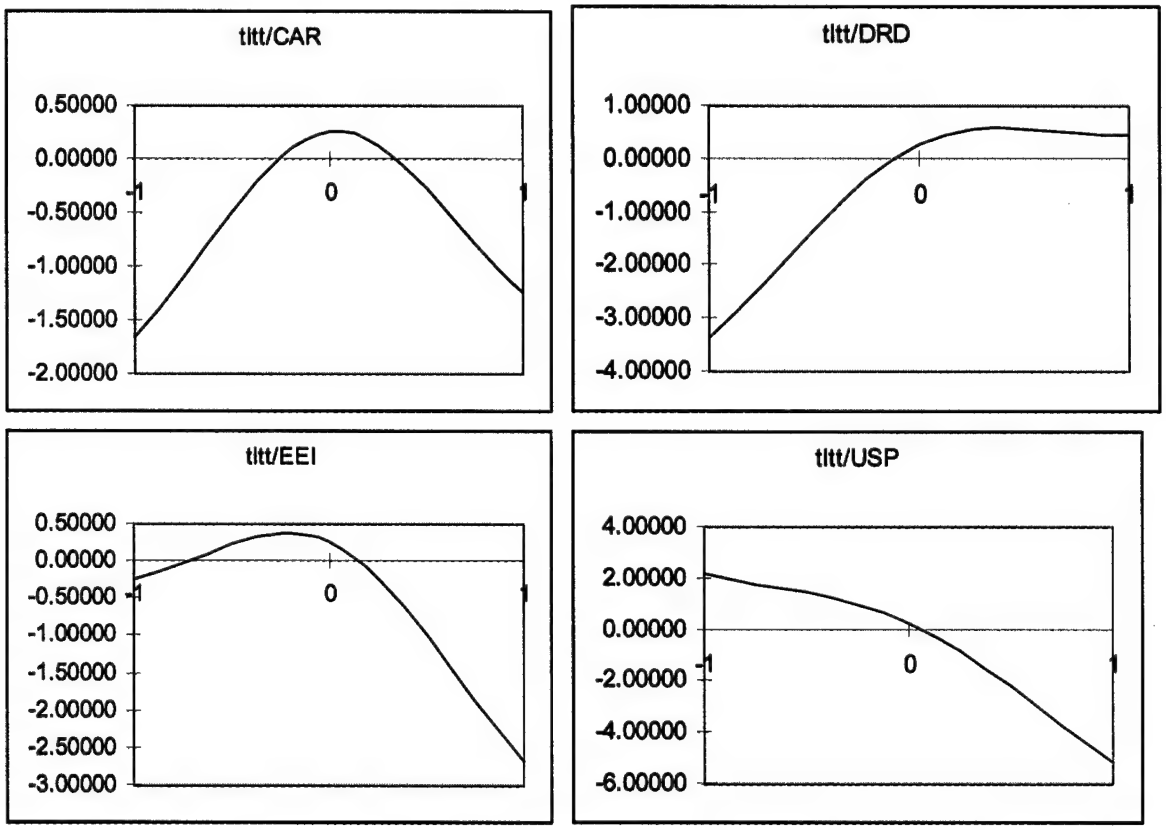
Regression ANOVA Summary Table				
Augmented 1-4 Replicate 2-5 Design				
	Alternative Regression ANOVA			
Number of center point treatments, n(cp) =		11		
Number of Data Points That Have Repeated Observations				
(T) (i.e., the replication of the Center Point) =		1		
Treatment Combinations, N (n(1/4) + n(cp) x T) =		19		
Source	**df**	**MS**	**F**	**P**
Regression	(5)			
CAR	1	8.946	147.130	<.0001
DRD	1	2.060	33.880	0.000
EEI	1	2.060	33.880	0.000
USP	1	24.290	399.470	<.0001
MRS	1	0.092	1.520	0.246
Residuals	(13)			
Lack Of Fit (LOF)	3	0.581	9.551	*Significant
Error ((n(cp) -1) x T)	10	0.061		
Total:	(18)			
Verification: N-1 =	18			

* From manual decision rule test.

Appendix J – Dependent Variable Response Plots

Dependent Variable Taskload From Tasktime - TLTT.

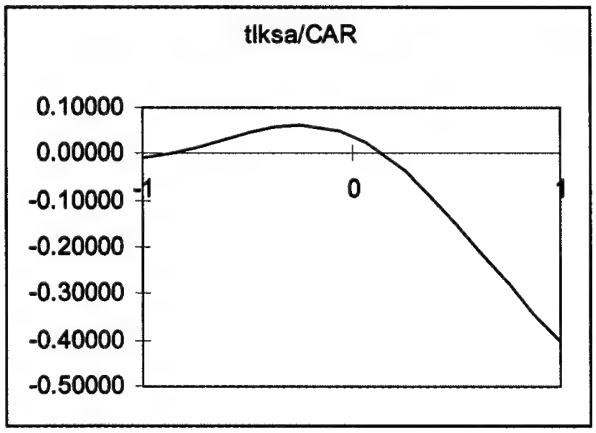
		tltt/CAR
Average of Sum of -1 data	-1	-1.65591
Average of Sum of 0 data	0	0.26333
Average of Sum of 1 data	1	-1.24072
		tltt/DRD
Average of Sum of -1 data	-1	-3.35114
Average of Sum of 0 data	0	0.26333
Average of Sum of 1 data	1	0.45451
		tltt/EEI
Average of Sum of -1 data	-1	-0.23939
Average of Sum of 0 data	0	0.26333
Average of Sum of 1 data	1	-2.65725
		tltt/USP
Average of Sum of -1 data	-1	2.22875
Average of Sum of 0 data	0	0.26333
Average of Sum of 1 data	1	-5.12538

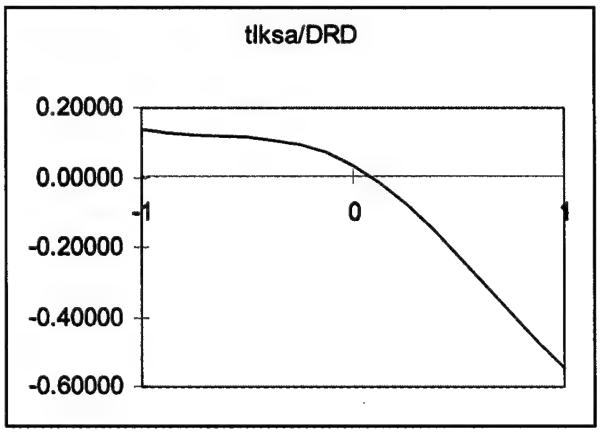


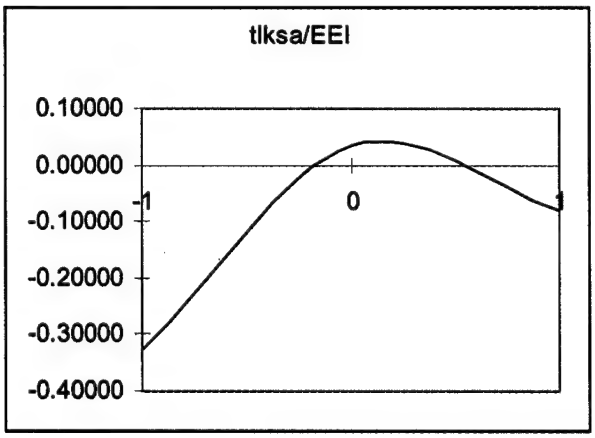
From these curves it is observed that all four independent variables, CAR, DRD, EEI, and USP invoke a quadratic response from the dependent variable TLTT.

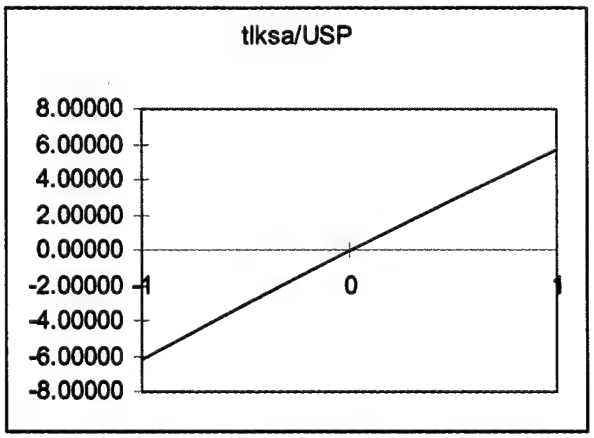
Dependent Variable Taskload From KSA - TLKSA.

		tlksa/CAR
Average of Sum of -1 data	-1	-0.00504
Average of Sum of 0 data	0	0.03703
Average of Sum of 1 data	1	-0.40224
		tlksa/DRD
Average of Sum of -1 data	-1	0.13808
Average of Sum of 0 data	0	0.03703
Average of Sum of 1 data	1	-0.54536
		tlksa/EEI
Average of Sum of -1 data	-1	-0.32674
Average of Sum of 0 data	0	0.03703
Average of Sum of 1 data	1	-0.08054
		tlksa/USP
Average of Sum of -1 data	-1	-6.14834
Average of Sum of 0 data	0	0.03703
Average of Sum of 1 data	1	5.74106





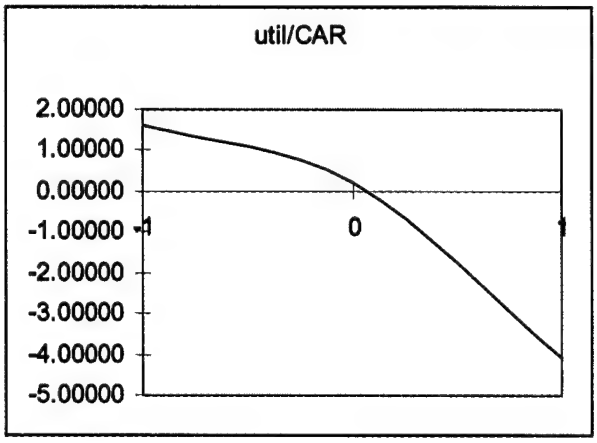


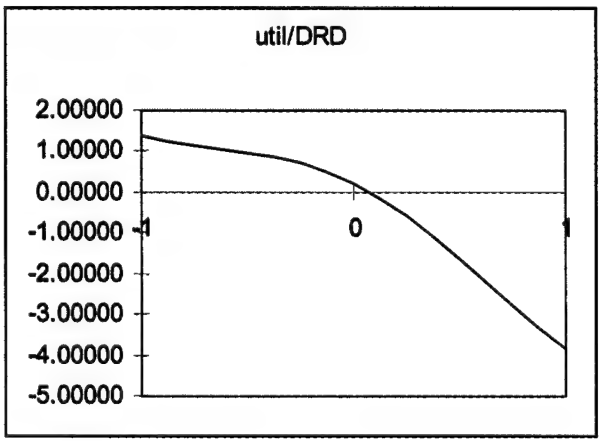


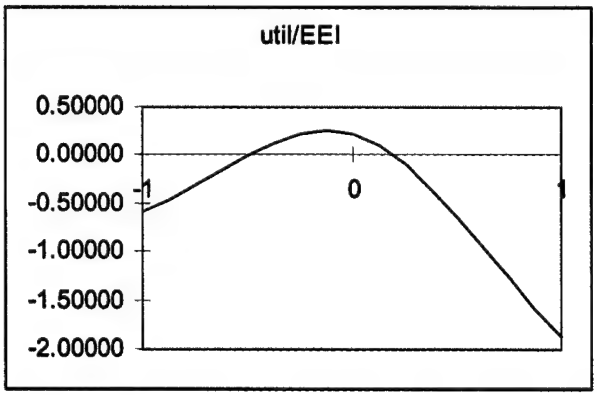
From these curves it is observed that three independent variables, CAR, DRD and EEI invoke a quadratic response from the dependent variable TLKSA and USP is linear.

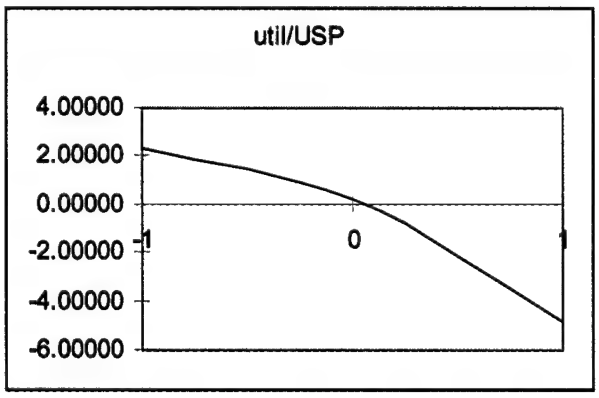
Dependent Variable Utilization - UTIL.

		util/CAR
Average of Sum of -1 data	-1	1.62394
Average of Sum of 0 data	0	0.22205
Average of Sum of 1 data	1	-4.06650
		util/DRD
Average of Sum of -1 data	-1	1.37103
Average of Sum of 0 data	0	0.22205
Average of Sum of 1 data	1	-3.81359
		util/EEI
Average of Sum of -1 data	-1	-0.58901
Average of Sum of 0 data	0	0.22205
Average of Sum of 1 data	1	-1.85355
		util/USP
Average of Sum of -1 data	-1	2.38266
Average of Sum of 0 data	0	0.22205
Average of Sum of 1 data	1	-4.82522





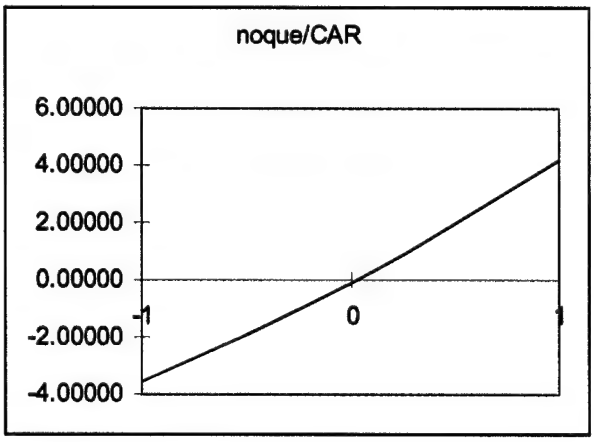


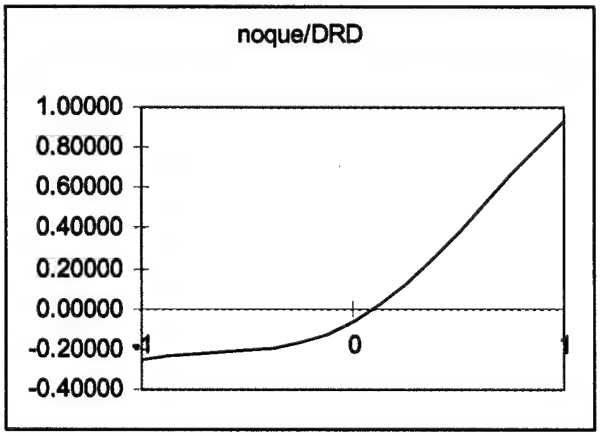


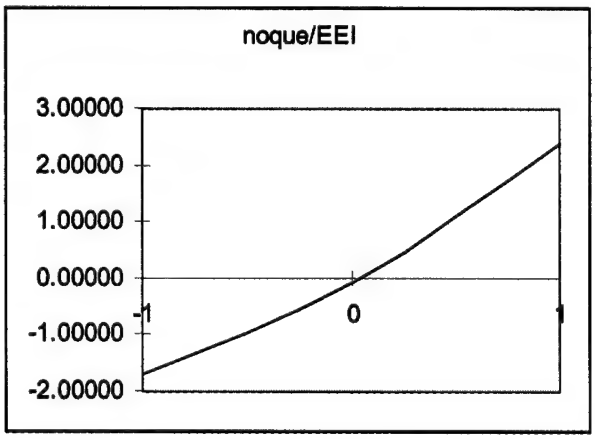
From these curves it is observed that all four independent variables, CAR, DRD, EEI, and USP invoke a quadratic response from the dependent variable UTIL.

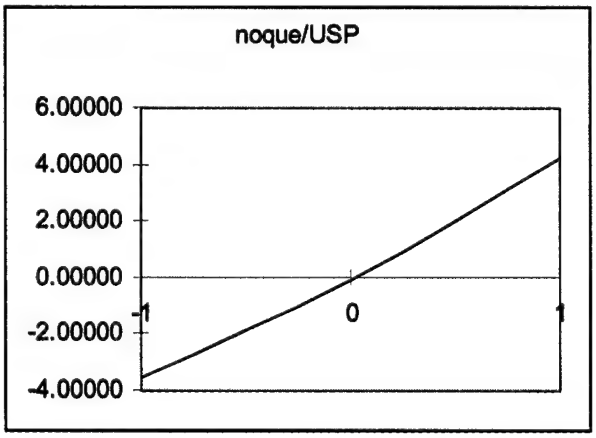
Dependent Variable Number of Queues - NOQUE.

		noque/CAR
Average of Sum of -1 data	-1	-3.52635
Average of Sum of 0 data	0	-0.06304
Average of Sum of 1 data	1	4.21977
		noque/DRD
Average of Sum of -1 data	-1	-0.24410
Average of Sum of 0 data	0	-0.06304
Average of Sum of 1 data	1	0.93751
		noque/EEI
Average of Sum of -1 data	-1	-1.68829
Average of Sum of 0 data	0	-0.06304
Average of Sum of 1 data	1	2.38171
		noque/USP
Average of Sum of -1 data	-1	-3.54932
Average of Sum of 0 data	0	-0.06304
Average of Sum of 1 data	1	4.24274





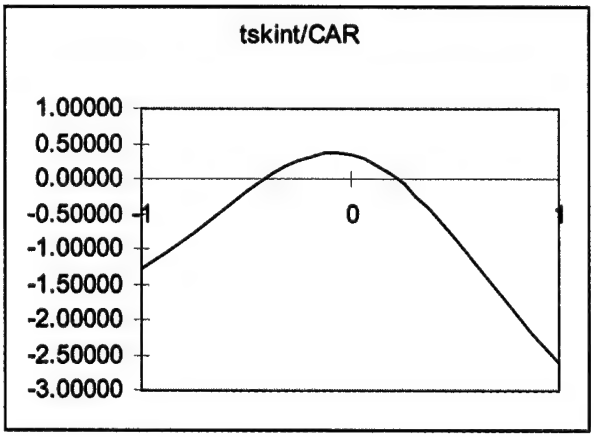


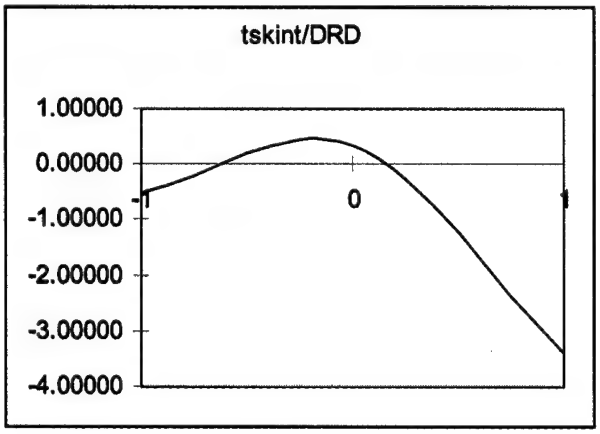


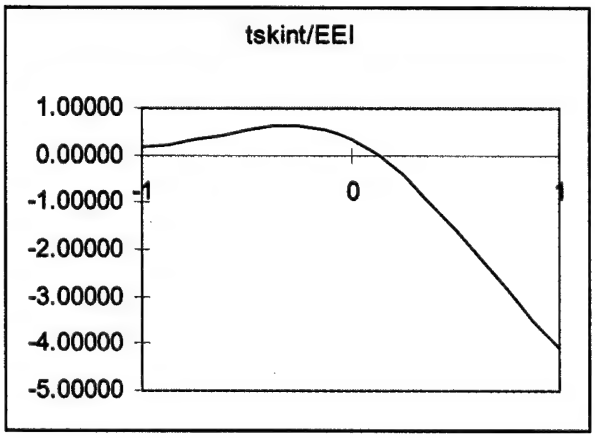
From these curves it is observed that the independent variable DRD invokes a quadratic response from the dependent variable NOQUE Variables CAR, EEI, and USP are linear.

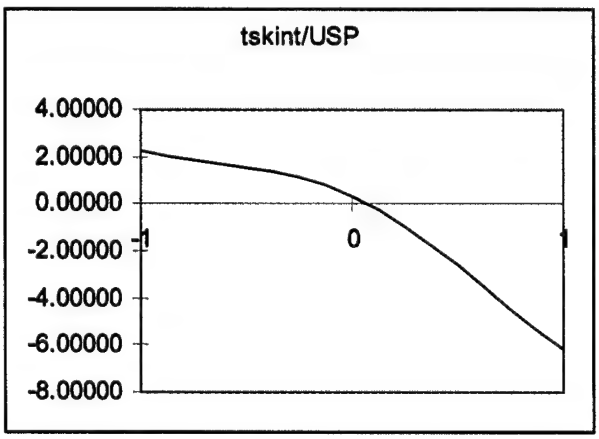
Dependent Variable Number of Task Interrupts - TSKINT.

		tskint/CAR
Average of Sum of -1 data	-1	-1.27595
Average of Sum of 0 data	0	0.35255
Average of Sum of 1 data	1	-2.60211
		tskint/DRD
Average of Sum of -1 data	-1	-0.50818
Average of Sum of 0 data	0	0.35255
Average of Sum of 1 data	1	-3.36988
		tskint/EEI
Average of Sum of -1 data	-1	0.18980
Average of Sum of 0 data	0	0.35255
Average of Sum of 1 data	1	-4.06786
		tskint/USP
Average of Sum of -1 data	-1	2.28373
Average of Sum of 0 data	0	0.35255
Average of Sum of 1 data	1	-6.16179





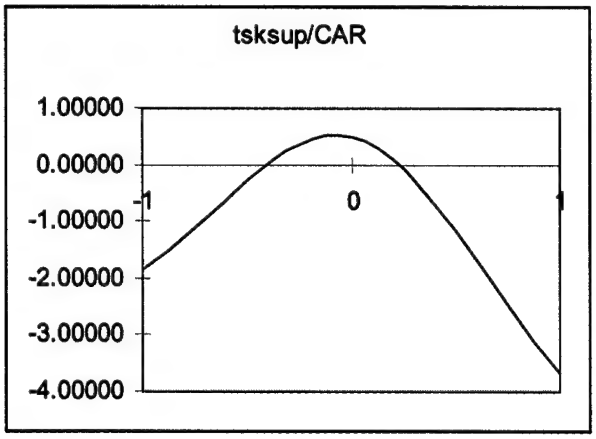


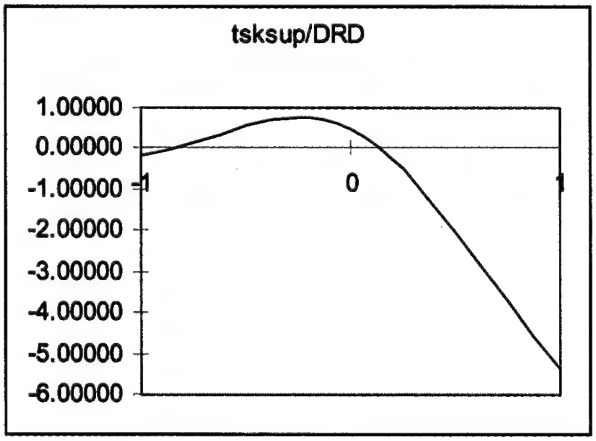


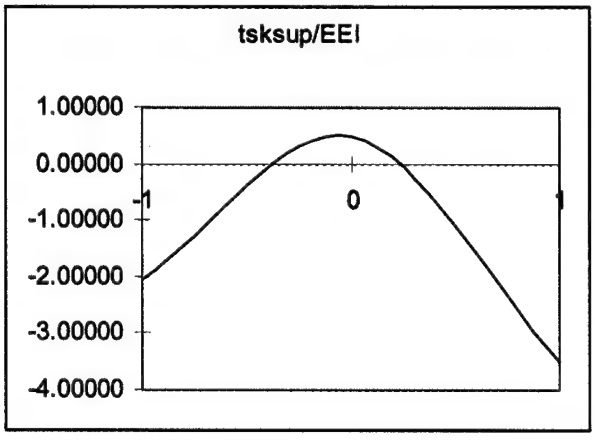
From these curves it is observed that all four independent variables, CAR, DRD, EEI, and USP invoke a quadratic response from the dependent variable TSKINT.

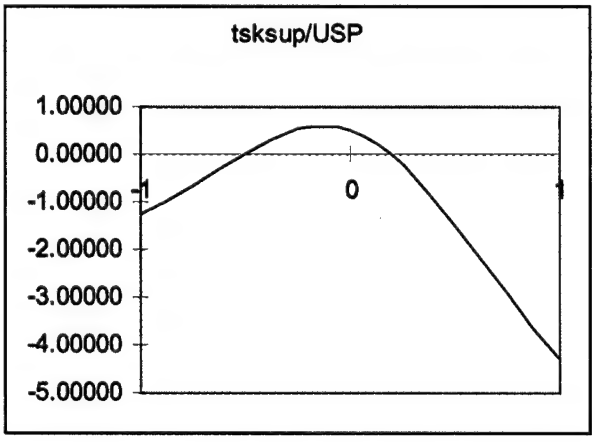
Dependent Variable Number of Task Suspensions - TSKSUP.

		tsksup/CAR
Average of Sum of -1 data	-1	-1.84628
Average of Sum of 0 data	0	0.50073
Average of Sum of 1 data	1	-3.66178
		tsksup/DRD
Average of Sum of -1 data	-1	-0.18463
Average of Sum of 0 data	0	0.50073
Average of Sum of 1 data	1	-5.32343
		tsksup/EEI
Average of Sum of -1 data	-1	-2.03090
Average of Sum of 0 data	0	0.50073
Average of Sum of 1 data	1	-3.47715
		tsksup/USP
Average of Sum of -1 data	-1	-1.23085
Average of Sum of 0 data	0	0.50073
Average of Sum of 1 data	1	-4.27720





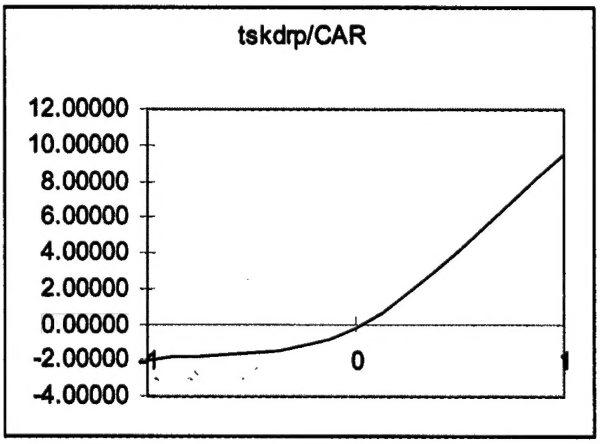


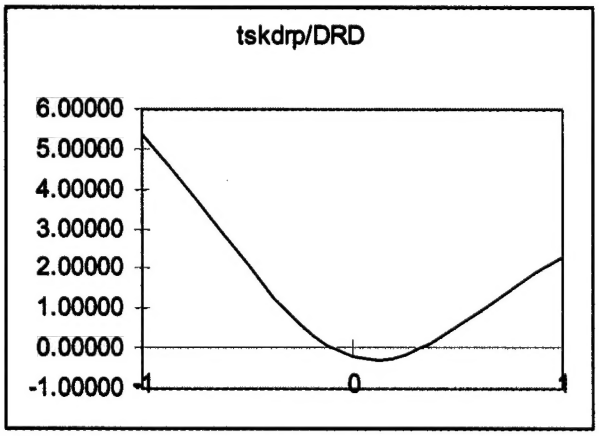


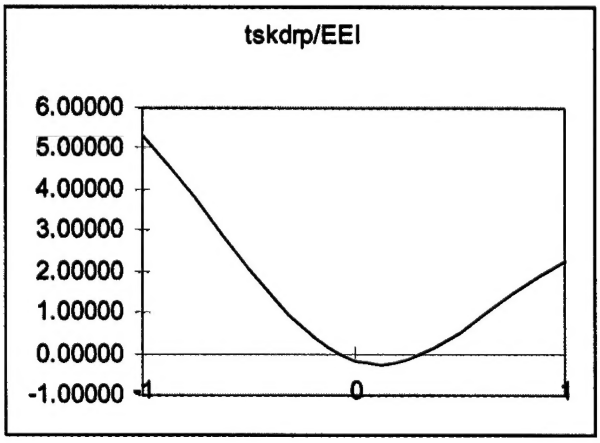
From these curves it is observed that all four independent variables, CAR, DRD, EEI, and USP invoke a quadratic response from the dependent variable TSKSUP.

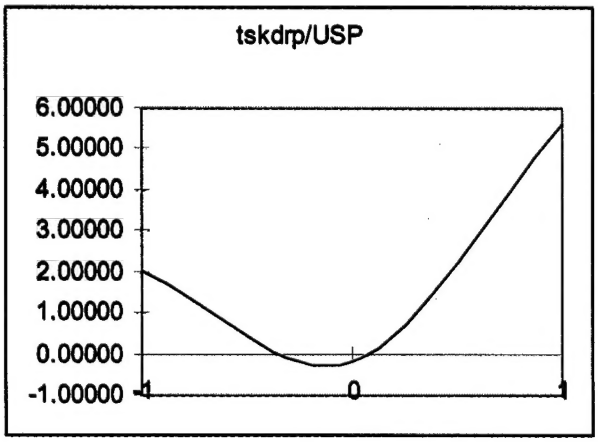
Dependent Variable Number of Task Drops - TSKDRP.

		tskdrp/CAR
Average of Sum of -1 data	-1	-1.92264
Average of Sum of 0 data	0	-0.16764
Average of Sum of 1 data	1	9.57071
		tskdrp/DRD
Average of Sum of -1 data	-1	5.36087
Average of Sum of 0 data	0	-0.16764
Average of Sum of 1 data	1	2.28720
		tskdrp/EEI
Average of Sum of -1 data	-1	5.36087
Average of Sum of 0 data	0	-0.16764
Average of Sum of 1 data	1	2.28720
		tskdrp/USP
Average of Sum of -1 data	-1	2.03873
Average of Sum of 0 data	0	-0.16764
Average of Sum of 1 data	1	5.60934









From these curves it is observed that all four independent variables, CAR, DRD, EEI, and USP invoke a quadratic response from the dependent variable TSKDRP.

VITA

Sam E. Middlebrooks, a career Federal Civil Service employee with over 20 years service, is a member of the Human Research and Engineering Directorate of the U.S. Army Research Laboratory at Aberdeen Proving Ground in Maryland where he is the Chief of the Command and Control Modeling Team. Previously, he was chief of the programming team at a joint U.S. Army and U.S. Air Force computer wargaming center in Germany and later became the director of the largest corps level battle simulation center in Europe. Sam holds a Bachelor of Science degree in Mechanical Engineering from the University of Texas at Arlington and is a retired U.S. Army Armor officer with operational experience in armored and cavalry units from platoon through corps levels. He entered the graduate program in Industrial and Systems Engineering (Human Factors option) at Virginia Tech in the Fall of 1997, part time off campus, and began full time studies in the Fall of 1999. He served as a graduate teaching assistant during the Fall semester of 2000 for the course "Human Factors Research Design I". His research interests are in simulation and modeling of human cognitive performance, especially in the area of military command and control. He is an active member of the Human Factors and Ergonomics Society and the Military Operations Research Society.

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11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This thesis research is involved with the development of new methodologies for enhancing the experimental use of computer simulations to optimize predicted human performance in a work domain. Using a computer simulation called Computer modeling Of Human Operator System Tasks (CoHOST) to test the concepts in this research, methods are developed that are used to establish confidence limits and significance thresholds by having the computer model self report its limits. These methods, along with experimental designs that are tailored to the use of computer simulation instead of human subject based research, are used in the CoHOST simulation to investigate the U.S. Army battalion level command and control work domain during combat conditions and develop recommendations about that domain based on the experimental use of CoHOST with these methodologies. Further, with the realization that analytical results showing strictly numerical data do not always satisfy the need for understanding by those who could most benefit from the analysis, the results are further interpreted in accordance with a team performance model and the CoHOST analysis results are mapped to it according to macroergonomic and team performance concepts.

The CoHOST computer simulation models were developed based on Army needs stemming from the Persian Gulf war. They examined human mental and physical performance capabilities resulting from the introduction of a new command and control vehicle with modernized digital communications systems. Literature searches and background investigations were conducted, and the CoHOST model architecture was developed that was based on a taxonomy of human performance. A computer simulation design was implemented with these taxonomic based descriptors of human performance in the military command and control domain using the commercial programming language MicroSaintT". The original CoHOST development project developed results that suggested that automation alone does not necessarily improve human performance.

The CoHOST models were developed to answer questions about whether human operators could operate effectively in a specified work domain. From an analytical point of view this satisfied queries being made from the developers of that work domain. However, with these completed models available, the intriguing possibility now exists to allow an investigation of how to optimize that work domain to maximize predicted human performance. By developing an appropriate experimental design that allows evaluative conditions to be placed on the simulated human operators in the computer model rather than live human test subjects, a series of computer runs are made to establish test points for identified dependent variables against specified independent variables. With these test points a set of polynomial regression equations are developed that describe the performance characteristics according to these dependent variables of the human operator in the work domain simulated in the model. The resulting regression equations are capable of predicting any outcome the model can produce. The optimum values for the independent variables are then determined that produce the maximum predicted human performance according to the dependent variables.

The conclusions from the CoHOST example in this thesis complement the results of the original CoHOST study with the prediction that the primary attentional focus of the battalion commander during combat operations is on establishing and maintaining an awareness and understanding of the situational picture of the battlefield he is operating upon. Being able to form and sustain an accurate mental model of this domain is the predicted predominant activity and drives his ability to make effective decisions and communicate those decisions to the other members of his team and to elements outside his team.

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14. SUBJECT TERMS

command and control; experimental designs; fractional factorial design; human performance; network simulations; polynomial regression; task and workload modeling

15. NUMBER OF PAGES
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16. PRICE CODE

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Item 13 (continued)

The potential specific benefit of this research to the Army is twofold. First, the research demonstrates techniques and procedures that can be used without any required modifications to the existing computer simulations that allow significant predictive use to be made of the simulation beyond its original purpose and intent. Second, the use of these techniques with CoHOST is developing conclusions and recommendations from that simulation that Army force developers can use with their continuing efforts to improve and enhance the ability of commanders and other decision makers to perform as new digital communications systems and procedures are producing radical changes to the paradigm that describes the command and control work domain.

The general benefits beyond the Army domain of this research fall into the two areas of methodological improvement of simulation based experimental procedures and in the actual application area of the CoHOST simulation. Tailoring the experimental controls and development of interrogation techniques for the self-reporting and analysis of simulation parameters and thresholds are topics that bode for future study. The CoHOST simulation, while used in this thesis as an example of new and tailored techniques for computer simulation based research, has nevertheless produced conclusions that deviate somewhat from prevailing thought in military command and control. Refinement of this simulation and its use in an even more thorough simulation based study could further address whether the military decision making process itself or contributing factors such as development of mental models for understanding of the situation is or should be the primary focus of team decision makers in the military command and control domain.